## I. PROJECT PRESENTATION

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<th>PROJECT TITLE</th>
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<td><em>Nano and micromechanics of soft matter systems</em></td>
<td><strong>ACT-95</strong></td>
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<th>PROJECT DIRECTOR</th>
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<td>Enrique Cerda Villablanca</td>
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a) Main researchers’ information

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<th>MAIN RESEARCHER (Complete Name)</th>
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<td>Marcelo Kogan Alterman</td>
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<td><a href="mailto:mkogan@ciq.uchile.cl">mkogan@ciq.uchile.cl</a></td>
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<td>Francisco Melo Hurtado</td>
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<td>Maritza Páez Collio</td>
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b) Associated researchers’ information

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<td>Roberto Bernal Valenzuela</td>
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<td>56-2-27181379</td>
<td><a href="mailto:roberto.bernal@usach.cl">roberto.bernal@usach.cl</a></td>
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<td>Raúl Cordero Carrasco</td>
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<td>Luis Eugenio Hamm Hahn</td>
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<td>Francisco Vivanco Avaria</td>
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II. EXECUTIVE SUMMARY

The Anillo 95 has helped to assemble a team of scientists with different areas of expertise to work on Soft Matter related problems. Our initial aim was to study materials that are dominated by the nano and microscales, such as lipid membranes, biofilms, coatings, solid and fluid films, and granular interfaces, that require a high level of interdisciplinary collaboration to control and tune their physical, chemical and biological properties. We expected to increase our ability to manipulate, synthesize and analyze these interfaces to explore their properties and prepare our own polymer membranes, lipid vesicles, nanoparticles, and coatings. We achieved these goals and now we can study physical and biological membranes, films, and coatings, from the point of view of their toxicity, antimicrobial properties, permeability, stiffness, strength, toughness, etc. In summary, the researchers and laboratories associated to the Anillo have strengthened their capacity to do Soft Matter science.

Along the past three years, we have published our research in high profile journals as Proceedings of the National Academy of Sciences; Biomaterials; Physical Review Letters; and ACS Applied Materials and Interfaces, and published in key journals in the area as Soft Matter Journal; Materials Chemistry and Physics; Biophysical Journal; Langmuir; Journal of Biomaterials Tissue Engineering, etc. Although it is too early to see the impact of our research, the papers of the Anillo have been published in journals of average impact index three and have produced until now a total of 101 citations. Our research has contributed to assess the mechanical properties of fruit cuticles, to understand the deformation of ultrathin films, to predict the fracture propagation in films, to find the mechanisms of folding in opened shell structures, to control the penetration of nanoparticles through cell membranes, to prevent aggregation of peptides associated with conformational diseases, to design new coatings for corrosion protection and antibacterial properties, etc. Many of these research projects are still running and the overall effect of the Anillo ACT-95 will be seen in the coming years.

Our publications also show the results of our training activities: a total of 22 undergraduate and graduate students, and five postdocs are coauthors of our publications. We have graduated 12 students and 11 have finished their Master or PhD thesis in the framework of the Anillo. There are also many undergraduate and PhD thesis works that are in writing process and will be defended during this year or the next. We also organized within the framework of Anillo a diverse group of postdoctoral fellows and four of them have now a Postdoctoral Fondecyt Grant. As part of our training activities we encouraged students to do internships abroad and participate in workshops and conferences. Our students were also part of the Chicago-Chile Collaboration Project. This program was intended to give research experience to undergraduate students from Universidad de Santiago de Chile and University of Chicago. Five of our students went to Chicago and 12 Chicago students visited our labs to participate in specific research projects.
We helped to organize the V School on Nanostructures and II Workshop on Nanotechnology during the third year of the project and organized several minor workshops along the three years of the project. These meetings included our own undergraduate and graduate students as speakers, exposing them to criticism. It was also an effective way to track the progress of ongoing projects. Additionally, we organized the weekly Seminar Series on Soft Matter related topics where researchers and students learned and discussed on different problems. In connection to this, an important number of collaborators visited us for short and long periods of time helping to give an international atmosphere to our labs. Several of them gave specialized short-term courses to train our students and participated in the Seminar Series.

Many of our first achievements have been made in close contact with our international collaborators. Researchers from U. Manchester (UK), U. Cambridge (UK), Oxford (UK), U. Massachusetts (Amherst, US), U. Chicago (Chicago, US), ESPCI (Paris, France), LPS (Paris, France), UPMC (Paris, France), ENL (Lyon, France), ENS (Paris, France), CIO (México), IBEC (Barcelona, Spain), U. Greifswald (Germany) and U. Barcelona (Barcelona, Spain) have participated in the papers published during the last three years, visited our country to collaborate in ongoing research projects, or participate in workshops and/or conferences. Reciprocally, the researchers of the Anillo also participated in numerous activities abroad as research visitors or invited speakers in seminars, workshops and/or conferences.

Different outreach activities were designed to students and general public to produce awareness about the importance of Soft Matter science. The International Year of Chemistry inspired the organization of six mini-courses on subjects related to Soft-Matter that were opened to the general community. Additionally, researchers from the Anillo actively collaborated in several outreach activities aimed at commemorating this special year. As a consequence, one of our researchers was repeatedly invited by the Chilean National Congress to give his opinion on nanotechnology issues. We have also been part of Open Laboratories activity organized by the Outreach Program Explora Conicyt, which encourages the main organizations related to the development of science, technology and innovation to open their doors to the school-age students. Finally, we also collaborated with the Undergraduate Program for Physics and Mathematics Education of the Universidad de Santiago de Chile to design new Classroom-based activities.
III. RESUMEN EJECUTIVO

El proyecto Anillo 95 ha permitido organizar un grupo de científicos con diferentes especialidades para trabajar en problemas de Materia Blanda (*Soft Matter*). Nuestra motivación inicial era estudiar materiales que son dominados por la nano y microescalas tales como membranas lipídicas, biopelículas, recubrimientos, películas sólidas y líquidas, e interfaces granulares, las cuales requieren un alto grado de colaboración interdisciplinaria para controlar y calibrar sus propiedades físicas, químicas y biológicas. Esperábamos incrementar nuestra habilidad para sintetizar y analizar estas interfaces para así explorar sus propiedades y poder preparar nuestras propias membranas poliméricas, vesículas lipídicas nanopartículas y recubrimientos. Todo lo anterior fue logrado y ahora podemos estudiar membranas, películas y recubrimientos, biológicas y físicas, desde el punto de su toxicidad, propiedades antimicrobianas, permeabilidad, rigidez, resistencia, tenacidad, etc. En resumen, los investigadores y laboratorios asociados al Anillo han incrementado su capacidad de hacer investigación en el área de Materia Blanda.

A lo largo de los tres años de funcionamiento del Anillo hemos publicado nuestros trabajos en revistas de gran difusión como *Proceedings of the National Academy of Sciences; Biomaterials; Physical Review Letters; y ACS Applied Materials and Interfaces*, y también en revistas propias del área como *Soft Matter Journal; Materials Chemistry and Physics; Biophysical Journal; Langmuir; Journal of Biomaterials Tissue Engineering*, etc. aunque es demasiado temprano para ver el impacto de nuestra investigación, nuestras publicaciones han sido publicadas en revistas con un índice promedio de tres y han producido hasta ahora un total de 101 citas. Nuestra investigación ha contribuido en específico a medir las propiedades mecánicas en cutícula de frutas, entender la deformación en películas ultradelgadas, a predecir la propagación de fractura en películas, a encontrar los mecanismos de plegado en cáscaras con aberturas, a controlar la penetración de nanopartículas en membranas celulares, a prevenir la agregación de péptidos asociados con enfermedades conformacionales, a diseñar nuevos recubrimientos con propiedades anticorrosivas y antibacteriales, etc. Muchos de estos proyectos se están todavía desarrollando y por tanto el efecto final del Anillo ACT-95 se verá en los años que vienen.

Nuestras publicaciones también muestran nuestras actividades de formación: un total de 22 estudiantes de pregrado y postgrado, y cinco postdocs son coautores de nuestras publicaciones. Dentro del proyecto Anillo se graduaron 12 estudiantes y otros 11 terminaron sus tesis de Magister y Doctorado. Hay también varias tesis de pregrado, magister y doctorado que están en proceso final de escritura y que serán defendidas durante este año o el próximo. Pudimos organizar dentro del marco del Anillo un grupo diverso de postdoctorantes de los cuales cuatro actualmente son becarios de Fondecyt. Como parte de nuestras actividades de formación se motivó
a nuestros estudiantes a realizar estadías fuera del país y participar en workshops y conferencias y ser parte de la iniciativa Chicago-Chile Collaboration Project. Este programa fue ideado para dar experiencia a estudiantes de pregrado de estudiantes de la Universidad de Santiago y la Universidad de Chicago. Cinco estudiantes nuestros fueron a Chicago y 12 estudiantes de la Universidad de Chicago visitaron nuestros laboratorios para participar en proyectos específicos.

También ayudamos a organizar la "V Escuela de Nanoestructuras y II Congreso Nacional de Nanotecnología" durante el tercer año del proyecto y organizamos varios workshops más pequeños a lo largo de estos tres años. Estas reuniones incluyeron a nuestros propios estudiantes de pregrado y postgrado como expositores para enfrentarlos a la crítica y fue también otra manera de hacer un seguimiento del progreso en sus respectivos proyectos. Junto con lo anterior, se organizó una sesión semanal de seminarios en Materia Blanda donde investigadores y estudiantes aprendieron y discutieron sobre diferentes problemas. En conexión con lo anterior, un número importante de colaboradores nos visitaron por periodos cortos y largos de tiempo dando una atmósfera internacional a nuestros laboratorios. Varios de ellos también dieron cursos cortos para ayudar en la formación de nuestros estudiantes y ofrecieron seminarios durante su visita.

Muchos de nuestros logros han sido hechos en cercanía con nuestros colaboradores internacionales. Investigadores de U. Manchester (Inglaterra), U. Cambridge (Inglaterra), Oxford (Inglaterra), U. Massachusetts (Amherst, EEUU), U. Chicago (Chicago, EEUU), ESPCI (París, Francia), LPS (París, Francia), UPMC (París, Francia), ENL (Lyon, Francia), ENS (París, Francia), CIO (México), IBEC (Barcelona, España), U. Greifswald (Alemania) y U. Barcelona (Barcelona, España) han participado en las publicaciones generadas por el Anillo, han visitado nuestro país para colaborar en nuestros proyectos de investigación, o participado en workshops y/o conferencias. De manera recíproca los investigadores del Anillo han participado en numerosas actividades en el extranjero como investigadores visitantes o expositores en seminarios, workshops y/o conferencias.

Diferentes actividades de difusión han sido diseñadas para estudiantes y el público en general para generar atención sobre el área de Materia Blanda. El año Internacional de la Química inspiró la organización de seis minicursos sobre temas relacionados a Materia Blanda que fueron abiertos a la comunidad. Adicionalmente, investigadores del Anillo colaboraron activamente en actividades para conmemorar ese año especial y como consecuencia uno de nuestros investigadores fue repetidamente invitado al Congreso Nacional para dar su opinión sobre temas de nanotecnología. También hemos sido parte de la actividad Laboratorios Abiertos, organizados por Explora-Conicyt, que aboga por que los laboratorios de investigación abran sus puertas a estudiantes de escuelas y liceos. Finalmente, investigadores del Anillo colaboraron con el programa de Licenciatura en Educación Física y Matemática de la Universidad de Santiago para diseñar nuevas actividades prácticas en la sala de clases.
IV. HIGHLIGHTS

**Fruit Cuticle Rheology:** *Measurement of stress and strain in fruit cuticles.* We developed experimental capabilities that allowed us to assess the mechanical properties of cuticles isolated from economically important fruits. We characterized the deformation mechanisms of these cuticles by using whole-field optical techniques (such as phase-stepping profilometry (PSP) and electronic speckle pattern-interferometry (ESPI)). These techniques enabled us to monitor the development of deformations fields (and microcracks) on isolated cuticles subjected to mechanical load. The samples were subjected to uniaxial tensile tests and biaxial tensile tests (bulge tests). Our work allowed us not only the comprehensive characterization of the deformation mechanisms of the cuticles, but enabled us to begin further efforts. Indeed, we are currently studying how to induce controlled changes in the mechanical properties of cuticles. Preliminary tests implied the application of controlled doses of UV radiation.

**Biological Membranes and Coatings I:** *Increasing the penetration of nanoparticles by capping with peptides.* To improve the delivery of nanoparticles to the central nervous system is crucial for therapy and diagnostic purposes. By changing the physicochemical properties of nanoparticles is relevant to improve the pharmaceutical behavior modifying their biodistribution, toxicity and elimination. We capped gold nanoparticles with different peptides to modify their surface to favor the interaction with biological membranes and the delivery to the central nervous system. In addition, we functionalized gold nanoparticles with peptides rich in arginines to enhance their interaction with membranes and the cell internalization. Finally, in order to improve the delivery of gold nanoparticles to the brain, we functionalized gold nanoparticles with a peptide that recognize the transferrin receptor in the blood brain barrier to facilitate the transcytosis. Our results were published in a high profile journal (Biomaterials) that also posted the enclosed figure.
Biological Membranes and Coatings II: Gold nanorods to destroy toxic aggregates of \(\beta\)-amyloid. The aggregation of \(\beta\)-amyloid is closely related to the neurodegeneration and development of Alzheimer’s disease (AD). A strategy for treating the disease could be reducing the formation of aggregates of \(\beta\)-amyloid. By using gold nanorods selectively bound to \(\beta\)-amyloid aggregates and irradiation with near infrared laser, we destroyed the toxic aggregates reducing also their neurotoxicity. This is very relevant for the development of a new therapeutic strategy for AD.

Designing Smart Packaging Films: Spiral Tearing of Thin Films.. After finishing the process of patenting our idea of spiral tearing in thin films (see “Film mince d’emballage à amorce de déchirure”), we have published a concise review of our findings in Soft Matter journal. We presented the main mechanisms to produce divergent spiral tears and showed how this idea can be used to unwrap a seal.

Controlling Deformation in Shells and Films: Folding of Opened Spherical Shapes. We discovered a family of approximately isometric, constant positive Gaussian curvature shapes that is in excellent agreement with experimental results of deformed shells (3D scans of compressed ping-pong balls) and simulations (tethered membrane simulations minimizing the stretching and bending energy). The analytic solutions that describe those shapes show an interesting class of flexible shells designed to self-seal. This type of shells is beautifully illustrated by pollen grains, a morphologically diverse group of cells found in flowering plants.

Smart Coatings and Ultrathin Film Characterization I: Near and Far From Threshold Analysis of Thin Films. We have arrived to a model explaining the wrinkling observed in an ultrathin floated membrane. A previous model showed that the standard buckling analysis was unsatisfactory to predict the wrinkling in ultrathin films. This motivated a new approach based on a far from threshold theory that assumed wrinkled membranes reach an asymptotic state where the stress is collapsed (zero) in one direction. We have applied this theory
to explain conflictive experimental results and published in a high profile journal (PNAS) a summary of our results. During the third year a publication was accepted in Physical Review Letters, showing new implications of our findings. Many of our international collaborators participated in the publication where we redefined the fundamental concept of a contact angle when the substrate is a thin floated elastic sheet.

**Smart Coatings and Ultrathin Film Characterization II: Polymers as coatings for corrosion protection of AA-2024 aluminum alloys.** Concerning hybrid polymers, the most relevant finding is that dual modification of the polymer, i.e., the incorporation of CeₓOᵧ doped ZrO₂ nanoparticles, introduces a current-potential response during anodic disturbance (activation-passivation). The latter reveals a self-healing ability of the coating. Further, from comparison of the properties of three hybrid silanol polymers, the length of the aliphatic chain in one of the precursors is determinant in the anti-biofouling properties of the resulting coatings. The longer the chain length, the greater the anti-biofouling effect (experiments carried out with *P. aeruginosa*). The vinyl type coating adhesion was also studied; surface functionalization by transesterification significantly improved the adhesion of the coating. Further, studying the microbiologically influenced corrosion (MIC) mechanism of *E.coli* in 316L stainless steel, revealed a MIC dependence on catalase activity, influencing oxygen reduction. Our results were published in three papers, and were the topic of two undergraduate theses and one PhD thesis works.

**Smart Coatings and Ultrathin Film Characterization III: Antibacterial materials: their preparation and mechanisms of action.** In relation to metal nanoparticle (AgNPs and CuNps) functionalized polyethylene (PE) nanocomposites and their antibacterial activity against *L.monocytogenes*, our most relevant finding encompasses the antibacterial mechanism of such nanocomposites. While the antibacterial action of the nanocomposites is mostly attributed to nanoparticle metal ion release, we demonstrated that penetration of AgNps and CuNps through the cell wall also participates in the biocidal ability of the nanocomposites studied. In addition, a systematic study of the antibacterial activity of fatty acid stabilized silver nanoparticles in water found remarkable differences in their capability to penetrate the bacterial cell. Moreover, a broader range of particle size of 5-96 nm compared to previously reported investigations, and a variable toxicity depending on the particles size, were observed. Silver nanoparticles stabilized with oleic acid showed clear advantages in antibacterial activity; penetration inside the bacteria cells, low cytotoxicity, time effectiveness, efficiency and stability against light. Further, we prepared materials for applications in medicine. Silver complexes synthesized with compounds of known anti-inflammatory ability were used to achieve a dual effect: antibacterial and anti-inflammatory activity, which also proved to be
photochemically and thermally stable. Our results were published in six papers, and were the topic of one PhD thesis work.

**Smart Coatings and Ultrathin Film Characterization IV: Liquid marbles, soft jamming of granular interfaces.** Coating is known to stabilize efficiently liquid interfaces. This property is broadly used in industrial context including pickering emulsions or foam stabilization. The combination of a relatively rigid grain-network with the soft nature of capillary interface can create unique new materials of tunable stiffness. Both components are of antagonistic properties: grains sustain only compression and are highly dissipative, whereas capillarity stores energy without dissipation and resist extension. We studied the mechanical response of such an interface, with large grains surface fraction and under slow compression (“creeping”). This is the region of parameters of interest for the stabilization properties since it occurs when the grain network jams. The network detailed structure is relevant for understanding their mechanics, thus we designed and experiment combining both mechanical and structural analysis. We evidenced that the network indeed jams, but in an original way as we did not observe any diverging mechanical property: the increase in rigidity occurs by jumps. For a low surface fraction, the interface behaves like a capillary interface, except for a slight compressibility effect of the grain network. Then at a larger surface fraction, the interface compressibility increases strongly and the interface acquires rigidity (J-point). Then a second increase is produced when the network reaches the maximal entropy (S-point) and finally the interfaces wrinkles at random close packing (W-point). These three successive states are illustrated from left to right on the figure. The drop shows history dependence and a large variability on the compressibility values which raises the question of the nature of the observed transitions. We describe these interfaces in the work frame of the Jamming transition.
V. ACTIVITIES

This section should have 5 pages as maximum extension. Indicate the activities performed during the entire period. Separate activities by numbered paragraphs. Each activity should have a headline with its name and 2-3 explanatory lines including if they have been performed and if not indicating why.

1. TRAINING & ORGANIZATIONAL ACTIVITIES

01. Web Site www.smat-c.cl
The web site www.smat-c.cl, which aims to connect different researchers interested in Soft Matter related problems, is our most important window to show the activities in the Anillo. The web site helps us to organize seminars and keep track of the activities of the Anillo, such as minicourses, workshops, calls for applications, disseminate outreach information, etc.

02. Seminar Series 2010-2013
Throughout the entire period, we held a weekly Seminar Series on Soft Matter related topics. It brought together researchers, visitors, professors, and undergraduate and postgraduate students interested in the research of our Anillo project (see details in Annexes 1).

03. Undergraduate Thesis Research Program
This program started on August 2010. We graduated a total of 10 physical engineering, biochemistry, pharmacist, and industrial chemistry students during the entire period of the Anillo and there are still ongoing thesis projects (see Annex 2).

04. Undergraduate Research Assistant Program
This program started on August 2010. It has been a continue source for our undergraduate thesis research program (see 03 above) and PhD students of our Anillo (see Annex 3).

05. Mobility Program
Following the first year progress report, we have encouraged students to do internships abroad and participate in national and international workshops in Chile (see Annex 4). Several of our PhD students have interned in laboratories abroad for extensive periods of time (see Annex 5).

06. Mini-Courses
Several minicourses were organized aimed at postgraduate students of the Departments of Physics and Chemistry of the Universidad de Santiago and Biochemistry of the Universidad de Chile (see details in Annex 6).

a. “Microscopía de Fuerza Atómica y sus aplicaciones en Biología”.
Professor Fausto Sanz from University of Barcelona gave a three day course in November 2012.

b. "An Introduction to Brittle Fracture Mechanics"
Researcher Mokhtar Adda Bedia from Laboratoire du Physique Statistique (France) gave a three day introductory course about fracture mechanics in October 2012.

c. “Electrochemistry of Immobilized Microparticles and Immobilized Liquid Droplets"
Professor Fritz Scholz from the Universität Greifswald (Germany) gave a four-day course in March 2012.

d. “Electronic Microscopy: Applications to Biology and Material Science”
Researcher Carmen López from the Universidad de Barcelona (Spain) gave a four-day course in November 2011.

e. “Nanotechnology to Improve Drug Delivery”
Professor María José Alonso from the Universidad de Compostela (Spain) gave a six-day course in December 2011.

f. “Structural Aspects and Methods in the Preparation of Lipid and Dendritic Nanoparticles”
Professor Eder Romero from the Universidad Nacional de Quilmes (Argentina) gave a four-day course in December 2011.

g. “Atomic Force Microscopy”
Professor Fausto Sanz from the Universidad de Barcelona (Spain) gave a three-day course in November 2011.

h. “Nanobiotechnology and Biosensors for Nanomedicine”
Professor Josep Samitier from the Instituto de Bioingeniería de Cataluña (Spain) gave a two-day course in December 2011.

i. “Microscopias de Sonda Próxima y sus Bioaplicaciones”
Professor Fausto Sanz from the Universidad de Barcelona (Spain) gave a three-day course in November 2010.

j. “Millifluidics: Capillarity and Interfacial Hydrodynamics”
Professor Jose Bico from the PMMH-ESPCI, Paris (France) gave a four-day course in November 2010.

07. Visiting Researchers
Researchers from universities around the world have visited our group. We were visited by the following collaborators along the entire period:

a. Third Year: Mokhtar Adda Bedia (Laboratoire du Physique Statistique, France), Silvia Goyanes (UBA, Argentina), Nancy Lis García (UBA, Argentina), Fausto Sanz (University of Barcelona, Spain), Josep Samitier (IBEC, Barcelona), Fernando Albericio (IRBB, Spain), Alejandro Sosnik (UBA, Argentina), Ernest Giralt (IRBB, Barcelona), Isabel Delgadoillo (Universidad de Guanajuato, Mexico), Amalia Martinez (Centro de Investigaciones en Optica CIO, Mexico), Holger Schilke (IMUK, Germany), Kevin Baker (University of Chicago, USA), Joel Marthelot (PMMH, ESPCI, France), John Berg (University of Konstanz), Benoit Roman (PMMH, ESPCI, France).

b. Second Year: Eleni Katifori (Rockefeller University, US), Jacques Dumais (Harvard University), Benoit Roman (ESPCI, France), Benny Davidovitch (University of Massachusetts, US), Juan Rayas (Centro de Investigaciones en Optica, Mexico), Damien Cuvelier (Soft Matter Interfaces, Institut Curie, France), Fritz Scholz, (University of Greifswald, Germany), Xiaorong Zhou (Corrosion and Protection Centre, School of Materials, University of Manchester, UK), Maria Jose Alonso (Universidad de Santiago de Compostela, Spain), Fausto Sanz (Universidad de Barcelona, Spain), Josep Samitier (Instituto de Bioingeniería de Cataluña, Spain), Carmen López (Servicios Científico-Técnicos, Universidad de Barcelona, Spain), Eder Romero (Universidad de Quilmes, Argentina), Helmut Cölfen (Universität Konstanz, Germany), Jean-Christopher Geminard (ENS-Lyon, France).

c. First Year: Professors Fausto Sanz (Universidad de Barcelona, Spain), José Bico (Ecole Supérieure de Physique et de Chimie Industrielles, France), Joseph Samitier (Instituto de Bioingeniería de Cataluña, Spain), Laurent Boué (Weizmann Institute of
Science, Israel), Juan Rayas (CIO, Mexico), Amalia Martínez (CIO, Mexico), Fritz Scholz (University of Greifswald, Germany), Bernard Tribollet (UPMC, France), Benoit Roman (ESPCI, France), Stephane Jobs (SUPMECA, France), Jean-Christophe Geminard (ENS), Valerie Vidal (ENS), Benny Davidovitch (U. Mass, US), Niels Holten (U. Chicago, US), and Robert Schroll (U. Mass, US).


Aimed at presenting the progress of the ongoing projects in the framework of our Anillo, we organized two conferences “Nano and Micro-Mechanics of Soft Matter Systems” in April 2011 and April 2012. These workshops took place at the Universidad de Santiago and included undergraduate and graduate students as speakers. (see details in Annex 7).

09. **Miniworkshop “Elasticity & Geometry**

We organized a miniworkshop in which 10 researchers from Harvard University, Universidad Adolfo Ibañez and Universidad de Santiago discussed their research work. The event took place in January 2012 (see details in Annex 8).

10. **V School on Nanostructures and II Workshop on Nanotechnology**

Researchers from the Anillo had an active participation in the organization of this meeting that took place in Universidad Federico Santa Maria (Valparaiso, Chile) in October 2012. One of our principal investigators (M. Kogan) was president of the Scientific Committee and three others formed part of the organizing committee. The meeting was organized by Anillo ACT-95 and by Universidad Federico Santa Maria. (see details in Annex 9).

11. **Chicago-Chile Materials Collaboration Project**

In the framework of the Chicago-Chile Materials Collaboration Project, a total of 12 students from the University of Chicago (UC) interned at our laboratories. The internships lasted ten weeks and UC students were put to work on Soft Matter related problems. During the Chilean summer vacations, four students in 2011 and one student in 2012 interned at the University of Chicago for the same period of time. Most of the funding for this Project was obtained from the US National Science Foundation through the program "Materials World Network: Cooperative Activity in Materials Research between US Investigators and their Counterparts in Chile" (DMR- 0807012). Although our Chicago colleagues applied for another 4-year extension of the project (see details in Annex 10), we could not renew the program. We expect in the near future to apply for new funding and continue this long-standing research and training collaboration.

12. **Postdoctoral Positions**

One of the successes of the project was to assemble a team of postdoctoral fellows. In the first year, we started with Manuel Ignacio Azocar who was already working with M. Páez at the time. We funded 3 postdoctoral positions during the second year of the process (Guillaume Lagubeau, Etienne Couturier and Ana Riveros) until October 2011. Two of our postdocs, Guillaume Lagubeau and Etienne Couturier, obtained funding for the period 2011-2014 in the Fondecyt 2012 Postdoctoral Grants Competition. A fourth postdoc (Robert Schroll) joined our team at the end of 2011 thanks to the same Fondecyt program. Finally, Ana Riveros obtained a Postdoctoral Fondecyt Grant for the period 2012-2015. It is remarkable the work of Manuel Ignacio Azocar who has contributed to many publications of the Anillo. He obtained an award for presenting the best research poster in the conference "12th International Symposium on Metal Ions in Biology and Medicine" and is also an editor for the new scientific journal "Communications In Inorganic Synthesis" that has been recently established. The team of postdoctoral fellows will accompany us until the end of their respective Fondecyt projects.
2. RESEARCH ACTIVITIES FOCUS AREA A (Fruit Cuticle Rheology)

01. **Insulation of fruit cuticles**
We were successful in insulating cuticles samples and studied their morphology in two ways: a) we applied phase-stepping profilometry (PSP) to retrieve topographic maps of cuticles isolated from the abaxial surface of leaves. Most of our attention went to retrieving the high-resolution elevation information from the cuticle surface, which included the traces left by ribs and veins. b) We used epifluorescence and confocal microscopy to characterize the distribution of cell wall thickness in fruit cuticles. This information explains the wide-range of elastic modulus measured and the stress focusing observed in a tensile test just before cracking.

02. **Development of traction test**
Strain localization induced by uniaxial tensile tests was monitored by electronic speckle-pattern interferometry (ESPI). Our measurements allowed us to evaluate the two relative in-plane displacements undergone by the tested cuticles and to evaluate the corresponding strains.

03. **Measurement of stress and strain in cuticles**
Phase-stepping profilometry (PSP) was also applied to monitor the whole-field out-of-plane deformation induced on fruit cuticles subjected to biaxial tensile tests (bulge test). These measurements allowed us to assess the maximum strain that can be induced on a cuticle before cracking. Strain localization induced by uniaxial tensile tests was monitored by electronic speckle pattern-interferometry (ESPI). These measurements allowed us to evaluate the two in-plane relative displacement components undergone by the tested cuticles and to evaluate the corresponding strains.

04. **Tracking of stress concentration in fruit cuticles**
We are now in a position to undertake stress-focusing characterization with the new equipment that includes a lab-built bright field microscope, a uniaxial tensile machine and a built-in U.V. light source to damage a portion of the sample where the displacement field is measured by means of particle imaging velocimetry algorithms.

05. **Microcrack Tracking**
We developed the optical facilities required to apply whole-field optical techniques to micrometric samples. We applied a speckle-based method (for generating the fringe patterns) and temporal phase-shifting (for retrieving the whole-filed values of the phase) to follow the microcrack development when applying tensile load on cuticles isolated from berries. We were able to measure the two in-plane relative displacement fields around the microcrack area and to evaluate the corresponding strains, stresses and rotation fields.

3. RESEARCH ACTIVITIES FOCUS AREA B (Living Biological Coatings)

01. **Ultrasound measurement of soft membranes**
We have developed a method to characterize membranes and successfully applied to assess thin protective coatings. Novel methods of elastography and echography are also operational. New research echography facilities are now available in our laboratories.

02. **Modeling wrinkled coatings**
A theoretical model was prepared, but it was not possible to validate it by using numerical simulations. This activity is on hold.
03. **Experiments on coated circular tubes**
We did some preliminary experiments, but there were technical difficulties to prepare the samples. The difficulties to work in rectangular geometries prevented us to work in circular geometry.

04. **Experiments on wrinkled coatings**
A physical engineering thesis was presented (Rubén Meza) with the main results of our findings. We found interesting experimental results that we have not published yet because of a lack of theoretical understanding of our data.

05. **Interaction of nanoparticles with polymer membranes**
Planar surface bilayers and liposomes were prepared. We are now studying the effects of nanoparticles on the bilayers by using atomic force microscopy and by fluorescence and Cryo-Tem. A young investigator incorporated to the Pharmaceutical Sciences Faculty at the University of Chile as an Assistant Professor (Felipe Oyarzun) with the program “Inserción de Capital Humano Avanzado en la Academia” of Conicyt and a new line of research related with the interaction of nanoparticles with polymers has been opened at the Faculty. An undergraduate thesis of Pablo Lara (Pharmacist) has been started in May of this year under the supervision of Marcelo Kogan and Felipe Oyarzun. The aim of the project is to encapsulate metal nanoparticles in microparticles of polymers (Chitosane, Alginate, etc) in order to improve their pharmaceutical behavior. On the other hand another undergraduate thesis is now in progress related with the study of the interaction of gold nanoparticles with polymers.

06. **Cryofixation: Morphological study of the interaction between Nps and lipid membranes**
We functionalized gold nanoparticles with Arg-rich peptides in order to increase the penetration of gold nanorods in cells for drug delivery purposes. We demonstrated the interaction of the nanorods with membrane models by Cryo-TEM, AFM, DLS and SAXS. Our work led to two new fondecyt projects in which MK and FM are principal investigators and coinvestigators (Fondecyt grants 1130425 and 1130922, respectively), a Posdoctoral CONICYT project and an undergraduate thesis.

07. **Cell culture growth on nanocomposites**
Chitosan was modified to increase its biocompatibility. We have tested the growth of cells on modified chitosan films. This work led to a Master Thesis and a publication.

08. **Interaction of nanoparticles with cells.**
We analyzed the interaction of nanoparticles with the protein corona that is formed in the presence of plasma or with biological medium. This interaction is determinant in the biodistribution of nanoparticles. Three papers have been published; an undergraduate thesis and two PhD theses have been developed. Moreover we studied the interaction of gold nanoparticles with β-amyloid involved in Alzheimer’s disease and the use of near infrared irradiation in order to destroy reduce the toxicity of the aggregates. The obtained results are relevant for the development of a new therapeutic strategy.

4.-RESEARCH ACTIVITIES FOCUS AREA C (Designing Smart Packaging Films)

01. **Packaging Industry**
We have started initial contacts with Nestlé-Switzerland to see ways to apply our patent to packaging. We tested different seals for Nestlé in May 2013 with positive and negative
outcomes. Finally, we participated in a meeting with the company Urgo (Paris, France) who were interested in applying our patent to their seals.

**02. Numerical Methods**

Numerical simulations have been implemented to study the concentration of elastic energy leading to fracture. In addition, a multi physics approach based on finite element methods has been applied to study buckling of thin plates.

**03. Study of Tear Lines**

This activity does not yet have reportable results. Instead of studying one tear line, we focus our research on the analysis of tearing in the configuration defined in activity 04 (see below)

**04. Pulling & Pushing of a Seal**

We first study fracture propagation obtained by pushing with a blunt object, and, second by pulling on a flap. A PhD student (Víctor Romero) finished his thesis studying the fracture propagation leading to divergent tears. We published an extensive review about this mode of fracture in Soft Matter (Romero et al. 2013, Soft Matter).

**05. Collapsed packages**

An experimental study of the geometry of collapse in vacuum-sealed bags has been undertaken. Postdoctoral fellow Robert Schroll is doing numerical work on this problem.

**06. Opening Packages**

After obtaining an International patent for our spiral opening method (developed in activity 04) at the end of 2010, we applied for an extension for the patent in Europe. Our patent is now under review.

**07. Pollen Grains & Seeds**

After our initial publication on pollen grain folding (Katifori et al. 2010, PNAS), we worked on *Dianella caerulea* and developed a set of solutions describing opening and closing of pollen grains in nonaxysimmetric geometries. Numerical simulations have been developed to compute these solutions and our findings will be published this year (Couturier et al. 2013, Soft Matter).

**08. 3D Scanning and Modeling**

We purchased a 3D scanner and used it to evaluate the deformation of shells. The device was fundamental to evaluate the analytical solutions in 07 (Couturier et al. 2013, Soft Matter).

**09. Flexible electronics**

This activity does not yet have reportable results.

5.-RESEARCH ACTIVITIES FOCUS AREA D (Controlling Deformation in Shells and Films)

**01. Numerical Methods to study thin metallic films on soft substrates submitted to compression forces.**

The multi-physics approach based on finite element method has been applied to study buckling of thin metallic plates and deformation of cylindrical tubes under load. In the case of thin metallic plates, results have shown differences with results obtained from theoretical models and requires an appropriate choice of the solver method and finer tuning of the physical parameters. This method has also been extended to include breakable mesh in order to be applied to fragile plates or surfaces under impact.
02. Wrinkling Methods to study thin films
A wrinkling method for the assessment of thin film has been developed. An image analysis system has been designed to measure both the features (amplitude and wavelength) of the wrinkling pattern and the dynamics of dislocation type defects in a thin gold film deposited onto a soft material such as PDMS. These tools are currently used in our laboratories for the assessment of wrinkles in films of graphite and magnetic materials.

03. LBT to study monolayers
A Langmuir system has been developed. We are investigating the mechanical properties of a monolayer of hydrophobic particles located on the surface of water.

04. Pressure Sensor
A suitable sensor is in operation and allows us to accurately measure the surface pressure of a granular film.

05. Measurements
Measurements of wrinkled patterns in granular layers under compression have been completed. The data analysis is in progress and will be finished by the end of 2013.

06. Wilhelmy Plate
A system is in operation that has been designed and built for granular layer surface evaluation.

07. Instabilities in monolayers
A novel instability has been discovered in monolayers made of micrometric hydrophobic cylinders. A full characterization of granular interface has been achieved with the tools described in items 2-6. The data analysis is in progress and will be finished by the end of 2013.

08. Film on Substrates
Aiming at exploring the potential application of wrinkling and folding to produce devices (channels) suitable for nano and micro-fluidity applications, a wide variety of films deposited onto soft substrata have been explored. These include, for instance, films made of a few layers of graphene. Although some preliminary results are available, we do not expect to achieve reportable results in the work frame of the present project.

09. Shear and Tension Tests
These methods are now available and they have proven useful to characterize granular interfaces under shear. Experiments in collaboration with French groups are in progress and will be part of the Ph. D. thesis of one of our student, Mrs A. Rescaglio.

10. Measurements
Measurements on granular films are completed.

11. Modeling
This activity does not yet have reportable results.

6. RESEARCH ACTIVITIES FOCUS AREA E (Smart Coatings and Ultrathin Film Characterization)

01. Theoretical Modeling
A full study has been completed to explain the Near Threshold (NT) and Far From Threshold (FT) wrinkled states in ultrathin films in circular geometry. A first paper was published in a high profile journal (Davidovitch et al. 2010, PNAS) and a long paper was published to explain our analysis (Schroll et al. 2011).
02. **NT and FFT in Rectangular Geometry**

We have used the previous ideas to obtain a systematic expansion that explains the transition between NT behavior and asymptotic regimes such as wrinkling and crumpling (Arza et al. 2013, J.of Phys.).

03. **Permeability**

We managed to fabricate ultrathin polymer films and float them on water. Tracking the collapse of bubbles under the film, we computed its permeability. Our results show that the mechanism for diffusion of gases through an ultrathin film is different than the diffusion in a macroscopic film made of the same material. A physical engineering thesis was presented (Marinka Quezada), but we are still trying to identify the mechanism behind our findings.

04. **Modeling AgNps in polymeric films**

We had difficulties in arranging collaboration with theoretical chemists, particularly associated with computational infrastructure required to work with clusters of metal atoms, which involve a large number of electrons, such as silver element

05. **Synthesis of functionalized AgNps**

Much of this work was developed as part of a PhD thesis completed ("Incorporation of silver and copper nanoparticles in polymer matrices of polyethylene. Development of polymer films with antimicrobial activity." Dr. Laura Tamayo) and also as part of postdoctoral work (Dr.Manuel Azocar) related to the study of antibacterial capabilities of silver nanoparticles.

06. **Synthesis of encapsulated AgNps**

Much of this work is part of a PhD thesis finished, titled "Polymer Hybrid Sol-Gel Type: Material Used as Potential Inhibitor of Microbiologically Influenced Corrosion in Aluminum Alloys", and two undergraduate theses titled "Corrosive behavior analysis of stainless steel 316l influenced microbiologically in the presence and absence of catalase" (Finished, Licenciado Sebastian Baeza) and "Incorporation of silver nanoparticles in sol-gel films as a potential bio-corrosion inhibitor in aluminum alloys" (in progress, Nicolas Leiva, chemical engineering)

07. **Synthesis of polymer matrices**

Much of this work is part of two PhD theses titled "Incorporation of silver and copper nanoparticles in polymer matrices of polyethylene. Development of polymer films with antimicrobial activity" (Finished, Dra. Laura Tamayo) and "Vinyl polymers as coating for corrosion protection of aluminum alloy AA-2024". (in progress, Lisa Muñoz)

08. **AFM analysis of AgNps**

The development of this area is part of a doctoral thesis finished ("Incorporation of silver and copper nanoparticles in polymer matrices of polyethylene. Development of polymer films with antimicrobial activity", Dr. Laura Tamayo) and also, as part of postdoctoral work (Dr. Manuel Azocar). AFM has been useful for finding critical experimental parameters on the size and aggregation of nanoparticles in polymer matrices.

09. **Mechanical properties of polymer matrices**

A technique has been developed to determine forces of adhesion of sol-gel-type polymers on substrates of aluminum. This clearly demonstrates the role of surface roughness on the adhesion of the polymers.

10. **AFM study of films**

Besides traditional morphological assays, this technique has allowed us to determine the relationship between the size and distribution of cerium oxide nanoparticles in silanol
coating and its ability to induce self-healing processes of aluminum surfaces exposed to corrosive environments.

11. **Antimicrobial properties of films**
This part of the research was carried out successfully in the context of the development of new antibacterial materials. The incorporation of nanoparticles of silver or copper, based on polymeric matrixes polyethylene and in a hybrid sol-gel type polymer has revealed the addition of the antibacterial property to the resulting material. Moreover it has been demonstrated that the type of functionalization of the nanoparticles is relevant in one hand, the size of the nanoparticle (limited aggregation) and secondly, their effectiveness and efficiency as an antibacterial agent (paper submitted to Journal of nanoparticle research).

12. **Microscopic study of biocorrosion**
We microscopically studied biocorrosion in an AA-2024 aluminum alloy and stainless steel (316L). The influence of two strains of *E. coli* on aqueous corrosion of stainless steel and the influence of a strain of *pseudomonasaeruginosa* on aqueous corrosion of an aluminum alloy were investigated. Both studies are part of a doctoral thesis (Nelson Vejar) and an undergraduate thesis (Sebastian Baeza).

13. **Electrochemical study of biocorrosion**
Electrochemical measurements carried out in the culture medium in the absence and presence of bacteria show that the presence of microorganisms promotes an increase in the kinetics of corrosion and consequently, also a larger number of local events corrosion. For aluminum alloys AA-2024, such a behavior is strongly reduced when using silanol type coatings, which have antifouling properties.

14. **Antimicrobial mechanisms**
Most of this work has been done by Manuel Azocar, as part of his work as a postdoc. There are three publications, one published, two submitted and one in preparation. We have developed a technique to determine bacterial metabolites in situ.

15. **Preparation of Tip Tests**
The colloidal probe technique has been successfully implemented and a wide variety of electrical and mechanical tests have been carried out. In particular, bacteria have been successfully grown on the surface of the colloidal micro-sphere, allowing their functionalization to study bacteria adhesion to stainless steel surfaces. Similar studies are in progress, aimed at to determine the influence of heat treatment given to aluminum alloys (AA-2024) on the adhesion of the bacterium *Pseudomona aeruginosa*. Further, there is another investigation in progress which aims to develop the technique to determine the antifouling properties of organic coatings. (1 paper published in Corrosion Science, and 1 in preparation)

16. **Bacterial Cultivation**
Bacteria have been successfully grown on the surface of the colloidal micro-sphere.

17. **Adhesion & AFM**
Besides the preparation of colloidal particles and their functionalization to determine bacterial adhesion, the adhesion of AFM tips, previously functionalized with suitable peptides, has been designed for recognition of Beta Amyloid.

18. **Adhesion Tests**
For the assessment of mechanical properties of anticorrosive films, a mechanical test has been designed to measure the energy for homogeneous peeling of a thin metallic substrate from a polymeric matrix. This work is part of a PhD thesis completed (Dr.Nelson Vejar).
7.-RESEARCH ACTIVITIES FOCUS AREA F (Surface Biomineralization in Films and Coatings)

01. Nanoindentation
Nanoindentation methods have been developed and are currently in use for the assessment of mechanical properties of lipid bilayers and bioceramics surfaces.

02. Nanoindentation in Bioceramics
Nanoindentation on the surface of CaCO3 is completed; a wide variety of supersaturation conditions have been explored. Data analysis and modeling will be completed in a few months. An article containing these results is in preparation.

03. Nanoindentation in Thin Films
Nanoindentation in lipid bilayers is in use and this technique is providing us with valuable insight into nanoparticle - bilayer interactions. Our main results have been included in a recent review published by the members of the group. Additional funding has been obtained to continue to investigate nano-particle bilayer interaction beyond the scope of this project.

04. Tension tests
A method of tension test has been implemented and is in use for the assessment of mechanical properties of anticorrosion films. In addition, several other techniques are now available in our laboratories. These include, adhesion, fracture energy, residual stress and poisson ratio assessment. A preprint is available.
VI. OUTPUTS

ISI PUBLICATIONS


NON-ISI PUBLICATIONS


OTHER ISI PUBLICATIONS OF THE GROUP (not resulting from this project)


11. S. Cabrera, A. Ipina, A. Damiani, R. Cordero, R. Piacentini, “UV Index values and trends in Santiago, Chile based on ground and satellite data”, Journal of Photochemistry and
Photobiology B, **115**, 73, 2012.


**PATENTS**


**THESES**

**THESES - Undergraduate (IP: in writing process, F: finished)**

1. "Resistencia mecánica a partir de la concentración de esfuerzos en un cascarón sometido a compresión axial fuerte", Nicolás Cabezas, Physical Engineering, Universidad de Santiago de Chile (IP). Advisor: **E. Hamm**.


9. “Estudio del efecto de la radiación UV en la permeabilidad de hojas de limón", Jorge Muñoz, (F-2013), Physical Engineering, Universidad de Santiago de Chile, R. Cordero.


19. “Propagación de una onda ultrasónica en un medio granular no consolidado seco o húmedo sometido a una fuerza de compresión estática normal”, Antonella Rescaglio, Physical Engineering, Universidad de Santiago de Chile, (F-2010). Advisor: F. Melo.


THESES - Master (Completed and in process)


THESES- PhDs (IP: in writing process, F: finished)

1. “Implicancias farmaceúticas de la conjugación de peptidos a nanopartículas de oro: sus efectos sobre la interacción con proteínas plasmáticas, la penetración celular y la toxicidad”, Simón Guerrero, PhD in Pharmaceutical Sciences, Universidad de Chile (IP). Advisor: M Kogan


5. “Inestabilidades Hidrodinámicas de lechos fluidizados”, Javier Contreras, PhD in Physics, Universidad de Santiago de Chile (IP). Advisor: F. Melo.

6. “Propiedades mecánicas de biomateriales: Desarrollo de Métodos experimentales”, Héctor Alarcón, PhD in Physics, Universidad de Santiago de Chile (F-2012). Advisor: F. Melo.
7. “Propagación de sonido en materiales granulares: Inestabilidades bajo perturbaciones sónicas”, David Espíndola, PhD in Physics, Universidad de Santiago de Chile (F-2012). Advisor: F. Melo.
8. “Bandas de cizalle en medios granulares y vidrios metálicos”, Franco Tapia, PhD in Material Science, Universidad de Santiago de Chile (F-2012). Advisor: F. Melo.
9. "Polymer Hybrid Sol-Gel type: Potential Use as Material Inhibitor on Microbiologically Influenced Corrosion of Aluminum Alloys", Nelson Vejar, PhD in Chemistry (F-2012). Advisor: M. Páez
10. "Incorporation of silver and copper nanoparticles in polymeric matrixes of polyethylene. Development of polymer films with antimicrobial activity”, Laura Tamayo, PhD in Chemistry (F-2012). Advisor: M. Páez
12. "Nanoparticles of zirconia doped with cerium nitrate in hybrid sol-gel coatings: effect on corrosion protection of aluminum alloy 2024-T3”. Evelyn González, PhD in Chemistry, Universidad de Santiago de Chile (F-2011). Advisor: M. Páez
13. "Obtención de Nanoesferas y Nanovarillas de oro con péptidos para potenciales bioaplicaciones", Carolina Adura, PhD in Chemistry, USACH (F-2011). Advisor: M. Kogan and M. Páez
14. “Propagación de impulsiones no-lineales en materiales granulares”, Francisco Santibáñez, PhD in Physics, Universidad de Santiago de Chile (F-2010). Advisor: F. Melo.

THESES- PhD´s (ongoing thesis projects)

1. “Efectos de espaciadores sobre la estructura y la estabilidad de peptidos-nanopartículas metálicas con aplicaciones farmacológicas”, Mónica Vera, PhD Chemistry, Universidad de Chile. Advisors: M. Kogan and M. Campos.
2. "Fractura en Superficies Delgadas", Juan Fuentealba, PhD in Physics, Universidad de Santiago. Advisor: E. Hamm.
4. “Nanopartículas metálicas unidas a compuestos de inclusión de ciclodextrinas para potenciales aplicaciones en sistemas inteligentes de entrega de fármacos”, Natali Silva, PhD in Chemistry, Universidad de Chile. Advisors: M. Kogan and P. Jara.
5. “Reología de un sistema granular bidimensional: Caracterización de eventos locales por fotoelasticidad”, Nelson Sepúlveda, PhD in Physics, Universidad de Santiago de Chile. Advisor: F. Melo.

6. “Medición de campos de deformación en películas delgadas mediante interferometría”, Francisco Martinez, PhD in Physics, Universidad de Santiago de Chile. Advisor: R. Cordero.

7. “Mecánica del ADN modificado por drogas que forman “Interstrand Cross-Linking”, Romina Muñoz, PhD in Physics, Universidad de Santiago de Chile. Advisor: F. Melo.

8. Claudia Sánchez, PhD in Physics, Universidad de Santiago de Chile. Advisor: F. Melo.

9. Felipe Aguilar, PhD in Physics, Universidad de Santiago de Chile. Advisor: F. Melo.

LIST COURSES, SEMINARS, CONFERENCES, WORKSHOP

COURSES


2. “Nanopartículas de oro funcionalizadas con péptidos para el diagnóstico y terapia de enfermedades neurodegenerativas”, Segunda Escuela Latinoamericana de Nanomedicina, M. Kogan, La Plata, Argentina (October 25-28, 2010).


SEMINARS

1. "Euler Buckling Revised", E. Cerda, Miniworkshop Elasticity & Geometry, Departamento de Física, Universidad de Santiago de Chile (January 4, 2012).

2. "Stress focusing and collapse of a thin elastoelastic sheet under constant pressure", E. Hamm, Miniworkshop Elasticity & Geometry, Departamento de Física, Universidad de Santiago de Chile (January 4, 2012).


4. “Stress focusing and collapse of a thin elastic sheet subjected to constant pressure”, E. Hamm, École Normale Supérieure de Lyon, (February 7, 2012).

5. “Stress focusing and collapse of a thin elastic sheet subjected to constant pressure”, E. Hamm, University of Massachusetts Amherst, (March 5, 2012).

7. "Measurements of the Surface Spectral UV Radiation in the Antarctic Peninsula", R. Cordero, Seminar Series SMAT-C, Departamento de Física, Universidad de Santiago de Chile, Santiago, Chile (December 13, 2011)


11. "Stress focusing and collapse of a thin elastic sheet subjected to constant pressure", E. Hamm, James Franck Institute, University of Chicago (November 14, 2011).

12. "Far From Threshold Buckling Analysis of Thin Films", E. Cerda, Departamento de Física, Universidad de Chile (March 23, 2011).


14. "Physical Characterization of Leaf and Fruit Cuticles", R. Cordero, Seminar Series SMAT-C, Departamento de Física, Universidad de Santiago de Chile (September 7, 2010).

15. "Metrología en Superfícies Ultradelgadas", E. Cerda, Seminar Series SMAT-C, Departamento de Física, Universidad de Santiago de Chile (November 2, 2010).


17. "Wrinkling and Folding for Metrology of Thin Films", E. Cerda, Departamento de Física, Universidad Federico Santa María, Valparaíso, Chile (October 28, 2010).

CONFERENCES & WORKSHOPS


27. "Debilitamiento por cizalle y colapso de burbujas en fluidos viscoelásticos", C. Sánchez, V. Vidal, F. Melo. XVIII Simposio Chileno de Física. La Serena-Chile (Noviembre 21-23, 2012)

28. "Cambios elásticos en el ADN generados por drogas que forman enlace cruzado interhebra", R. Muñoz, L. Caballero, F. Melo. XVIII Simposio Chileno de Física. La Serena-Chile (Noviembre 21-23, 2012)


42. "Estudio de la estabilidad en medios biológicos y efectos sobre la viabilidad celular de nanopartículas de oro conjugadas con péptidos". E. Salas, M. Guerrero, M. Kogan. XXIX Jornadas Chilenas de Química. Quinamávida-Chile. (November 8, 2011).

43. "Formación de pliegues durante el colapso de una lámina delgada sometida a descompresión", E. Hamm. XVII Simposio Chileno de Física. Pucón-Chile (November 10, 2010).


45. ”Nanomateriales para el desarrollo de nuevas herramientas de diagnóstico y tratamiento”, M. Kogan. LV Reunión Científica Anual Sociedad Argentina de Investigación Clínica. Mar del Plata-Argentina (November 17, 2010).


OUTREACH

During 2010-2013 we developed the following outreach activities:

Third Year

1. "II Congreso del Futuro" organized by the National Congress of Chile in October 18th, 2013. The meeting was organized by the Chilean Senate Chamber that invited two Nobel laureates and several Chilean National Science Prize. It was aimed to a non specialized audience of 1500 people. One of our principal investigators (M. Kogan) gave the conference "Nanotecnología y salud: pasado, presente y futuro" (see http://www.youtube.com/watch?v=da71HPyNxnM).

2. Carlos Cantero, a senator in the National Congress of Chile interviewed M. Kogan in the TV Program "Nuevas Miradas". The aim of this interview was to diffuse to the public the applications of nanoparticles for treatment and diagnosis of different pathologies. This interview was emitted in public television in TVSenado Channel (see http://www.youtube.com/watch?v=mlrNo34OTk)

Second Year

1. Open Laboratories: High school students from the Metropolitan Region learned about soft materials (see Annex 11)

More than 100 students from Elvira Errázuriz School in the municipality of Ñuñoa, Peter College in Cerrillos, and Alicante School Maipú participated in the activity. The Open Laboratories activity is organized by the Outreach Program Explora Conicyt, which encourages the main organizations related to the development of science, technology and innovation to open their doors to the school-age students. We offered two sessions for this activity this year.

Researchers from the Nano and Soft Matter Systems Group taught some fundamental ideas about soft materials (rheology, thin films, capillarity) in demonstrative workshops in which they presented laboratory experiments and simple demonstrations of physical phenomena, accompanied with explanations in presentations entitled "Rheology: How materials flow?" and "Fracture in thin films: How to open a package?" and "Surface effects in liquids".

This activity took place in October 2011 in the facilities of the Physics Department of the Universidad de Santiago de Chile.

Teachers validate this initiative. In their own words, thanks to this activity, their students have a better understanding of what physics is and how physicists work.
2. **Classroom-based outreach activities: Improving science education in Chilean schools** *(see Annex 12)*

The chemistry, biology and physics classes of more than 150 students from Preciosa Sangre School Nº 99 were upgraded with new ideas and experiments undertaken by students from the Undergraduate Program for Physics and Mathematics Education of the Universidad de Santiago de Chile (Constanza Jaque and Roberto Yáñez).

Researchers from the Nano and Micromechanics of Soft Matter Systems Group have embarked on the ambitious project of working with the basic and high school study programs of the Ministry of Education. The objective is to add Science units on Soft Matter, incorporating scientific concepts related to this area of research to the Science curriculum.

In the case of basic level education there is the added advantage that chemistry, biology and physics are part of the same program (natural sciences = soft matter), which can be taught by students from the Physics and Mathematics Program of the Universidad de Santiago. This coincides with the interest of the Explora Program of CONICYT to strengthen science education in Chilean schools.

The first activities with the fourth and eighth grade students of the Preciosa Sangre School in Ñuñoa took place during the second semester of 2011. They were much appreciated by the students and the teachers.

3. **International Year of Chemistry**

The international year of Chemistry provided the members of the Anillo with the opportunity to collaborate in several outreach activities:

- **a.** "The good, the bad, and the ugly in nanochemistry". This general talk was prepared and given by Professor M. Kogan in the seminar series "Los Miércoles en la Academia" organized by the Chilean Academic of Science and Explora-Conicyt. Aimed to a broad audience, it showed novel lines of research in nanochemistry to an audience of more than 100 people *(see https://www.youtube.com/watch?v=SVy3D5WZtTk and Annex 13)*.

- **b.** "Corrosion Control of Aluminium Alloys for Aircraft Application". A talk presented to The International Air & Space Fair (FIDAE) for Professor X. Zhou who is an international research collaborator of our colleague M. Páez. Approximately 100 participated in this activity *(see Annex 14)*.

- **c.** Professor Fernando Albericio, Head of the Parque Científico de Barcelona *(PCB)* was invited by Professor M. Kogan to give a general talk and explain how research is organized in the PCB. Approximately 80 people participated in this activity *(see Annex 15)*.

5. "Piensa, Crea, Imagina y Descubre: Bioquímica de lo Macro a lo Nano". Presentation given by M. Kogan's student Komal Dadlani to 100 students in the activity organized by Explora-Conicyt "1000 Científicos 1000 aulas" (October, 2011).


First Year

1. "Miremos las Células" (Let's take a look at Cells), R. Bernal. Outreach activity for students at the CELEI School, Lo Prado - Santiago (May 22, 2010).


3. "XVIII Olimpiada Metropolitana de Física", E. Cerda and R. Bernal. Two of our researchers helped to formulate questions for the Physics Competition that took place at the Universidad de Santiago (September 24, 2010).

4. "El aporte al Bicentenario", An article was prepared for free mass distribution in Chile explaining the goals of our research group. The article was published in the newspaper La Segunda (August 12, 2010).
VII. LESSONS LEARNED

The following section can be used in case of available information related to the possible difficulties, inconveniences or similar issues in the management of the project within the host institution, between CONICYT and the host institution, institution and researchers or any other combination of participants and activities involved. The idea is to resolve these issues on behalf of better practices in the current and future handling of these initiatives.

Information provided in this section must be concise, stating all variables involved and outcomes. Do not extend further than 2 pages.
VIII. INDICATORS

The following section is has no further purpose but to organize some of the previous information. **Indicators have only statistical reasons to be asked for. If you require or would like to define indicators particular to your activities, results or impact please let us know including them at the end of this table.** This program is aware that quantitative indicators do not cover most of the actual impact of your activities and thus they are not evaluated.

<table>
<thead>
<tr>
<th>General</th>
<th>Discipline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total project budget</td>
</tr>
<tr>
<td></td>
<td>Percentage of the project costs contributed by non-governmental sources</td>
</tr>
<tr>
<td></td>
<td>N° of main researchers</td>
</tr>
<tr>
<td></td>
<td>N° of associated researchers</td>
</tr>
<tr>
<td></td>
<td>Gender (%) of the previous categories</td>
</tr>
</tbody>
</table>

| Scientific production | Nº of ISI publications | 57 |
|                       | Nº of non-ISI publications | 6 |
|                       | Percentage of co-authored publications with researchers not participating in the project | 100% |
|                       | Percentage of co-authored publications between Researchers of this project | 23% |
|                       | Average impact index of journals with ISI | 3.2 |
|                       | Publications resulting from this project | 39 |
|                       | Average number of citations per article | 2.6 |
|                       | Nº of presentations in international congresses | 34 |
|                       | Nº of presentations in national congresses | 15 |

| Commercial results or others | Nº of patents applied | 1 |
|                             | Nº of patents registered | 1 |
|                             | Nº of licenses and/or material transfer agreements | 0 |
|                             | Nº of Spin-offs | 0 |
|                             | Percentage of the annual funding of the project received from private companies | 0 |
|                             | Nº of spin-offs | 0 |
|                             | Nº of applications from results directed to other sectors Than academic (private, public, schools) | 0 |

<p>| Training of young researchers and students | Nº of undergraduate students | 20 |
|                                           | Nº of Master’s students | 2 |
|                                           | Nº of Ph.D. students | 24 |
|                                           | Nº of postdocs participating in the project | 5 |
|                                           | Nº of undergraduate theses finished | 12 |
|                                           | Nº of graduated theses finished (Master) | 1 |</p>
<table>
<thead>
<tr>
<th>Dissemination and extramural activities</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>N° of graduated theses finished (Ph.D.)</td>
<td>10</td>
</tr>
<tr>
<td>Percentage of theses co-tutored by researchers participant in this project</td>
<td>13%</td>
</tr>
<tr>
<td>Percentage of theses co-tutored with researchers external to this project</td>
<td>4%</td>
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<tr>
<td>N° of stays/visits to other centers/institutions by students or researchers of this project</td>
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<tr>
<td>N° of stays/visits from students or researchers of other centers or institutions</td>
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<tr>
<td>N° of other projects related or within this/activities with national collaboration</td>
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<td>N° of other projects related or within this/activities with international collaboration</td>
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</tr>
<tr>
<td>N° of public or private entities (not enterprises) involved in this project</td>
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<tr>
<td>N° of dissemination/extramural events</td>
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<tr>
<td>N° of times the project appears in mass media</td>
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<tr>
<td>Total N° of attendants to extramural events</td>
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<tr>
<td>N° of national academics attending</td>
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<tr>
<td>N° of international academics attending</td>
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<tr>
<td>N° of attending representatives from other sectors than academic</td>
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</tr>
<tr>
<td>N° of documents, reports, proceedings resulting from dissemination/extramural events or activities</td>
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</tr>
</tbody>
</table>