Up Close: Universidad Autónoma de Madrid

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This article is part of a series focusing on the research capabilities and goals of interdisciplinary laboratories pursuing materials research in universities, industry and government.

The Universidad Autónoma de Madrid was established by the Spanish Ministry of Education in 1968 to cope with increasing demands for student posts in the Madrid area. It was also established as a pilot university to provide experience for a more autonomous management of Spanish universities.

The present campus at Cantoblanco (14.5 km from the center of Madrid) was inaugurated in 1971, and since then the student population has grown from fewer than 10,000 students to more than 30,000. Nicolás Cabrera, a renowned Spanish solid-state physicist exiled after the Civil War, was the head of the initial Physics Department. Subsequent staffing increases and the development of new academic activities have resulted in the present arrangement with three departments of physics—theoretical physics (mostly high energy and nuclear physics), condensed matter physics, and applied physics. The latter two departments together cover many aspects of solid-state physics and materials science. An overview of the research efforts will now be presented for these two departments.

Applied Physics Department

The Applied Physics Department, with a permanent staff of 32 members (including full and titular professors), has the following main research lines: crystal growth, EPR and optical spectroscopy of defective crystals, bi-dimensional materials (superlattices) and phase transition materials for tunable solid-state lasers, photorefractive materials and nonlinear optics, solar energy materials and processes, laser annealing, and diffusion-enhanced reactions.

More specifically, the Crystal Growth Laboratory grows alkali halides and polyhalides, KDP-family crystals, ferroelectric and photorefractive materials such as $LiNbO_3$, BGO, BSO, and II-VI semiconductors (CdTe and the ternary Cd Hg Te). With alkali halides, the formation of suitable aggregated centers, F_2^+, for laser action is being undertaken and the stabilization role of cation and anion impurities on those centers is being investigated.

Electro-optic oxides, particularly $LiNbO_3$ are being thoroughly studied in connection with their photorefractive response. The role of impurity doping, crystal stoichiometry, irradiation, and oxidation/reduction treatments take most of the effort. Novel information about intrinsic (vacancy) defects in $LiNbO_3$ is being inferred from those studies, including high-energy electron irradiations performed at CIEMAT (Madrid).

Condensed Matter Physics Department

The study of the electronic properties of III-V superlattices is being actively pursued in cooperation with theoreticians of the Condensed Matter Physics Department and some laboratories (Max Planck, IBM, and others). The technique primarily used is Raman spectroscopy. A superconducting magnet has been installed to investigate the effect of (high) magnetic fields.

The Condensed Matter Physics Department has a permanent staff of 21 members (including also full and titular professors). This department maintains a strong theoretical effort in solid-state physics, with 10 members of the permanent staff working on surface physics, superlattices, superconductivity, disordered systems, and statistical mechanics. The work on theoretical surface physics is quite broad, ranging from semiconductors and their interfaces to the analysis by the scanning tunneling microscope. All this work is partly connected with several experimental groups of the same department working mainly on surface physics, low temperatures and superconductivity, and scanning tunneling microscopy.

The surface physics group is currently involved in the epitaxial growth of thin crystalline films, the chemical reactivity of surfaces, metal-semiconductor interfaces, and the magnetic properties of low-dimensional systems. This research involves the use of numerous different techniques, such as LEED, AES, HREELS, IPS, XPS, and STM.

The low temperature and superconductivity group has been traditionally involved with glassy and ferroelectric materials, with heavy fermions systems, and more recently with the novel superconductors. They are currently using different techniques to measure spontaneous polarization, heat capacity, thermal expansion and thermal conductivity in the 0.3-3 K range. They have been also working with STM spectroscopy at low temperatures.

The STM group focuses mainly on applying the tunneling microscope to different areas of physics and biology. We would like to mention that this group was the first to show the possibility of having the microscope operating in the open air without any vacuum system.

Materials Science Institute

In the last academic year, the university has created the Materials Science Institute. Through this new institute, the university is attempting to combine the experience of the Departments of Applied Physics and Condensed Matter Physics in order to start a new project directed not only toward basic research but toward a technical collaboration with the industrial environment currently flourishing around Madrid.

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Up Close in November: Institute of Electronic Structure and Lasers, Research Centre of Crete