CMD2020GEFES mini-colloquium

Strain in Metal-Halide Perovskites and other Emerging Nanomaterials

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Whereas unintentional static strain in practical devices has been regarded as a feature to avoid for many years, strain engineering is nowadays ubiquitously used, e.g., to enhance the carrier mobility in transistors or to achieve lasing at reduced current densities in heterostructure systems. This is due to the fact that the physical properties of materials ultimately depend on the inter-distance between their constitutive atoms. As a natural consequence, the electrical, magnetic and optical response of materials can be tailored by modifying their deformation state. This strain-modulated control is especially interesting for the case of nanomaterials where size-dependent quantum confinement effects become relevant for a wide range of applications in quantum technologies.

In this symposium, we will focus on the recent progress on the static and elastic strain engineering of the optical and phononic properties of nanomaterials including metal halide perovskites nanostructures, nanowires, van der Waals bidimensional materials or quantum dots. We will cover advances on the active strain tuning of their physical properties as well as the influence of strain on the performance of nanomaterials for practical applications.

The first part will focus on “strain in metal halide perovskites”. This reborn family of materials show excellent optoelectronic properties such as strong light absorption, long charge carrier diffusion lengths and high radiative recombination yields. These factors have put them at the forefront of the emerging photovoltaic and lighting technologies. Recently, strain has been proven to correlate with the presence of defects in these materials, with a detrimental effect in the final performance of devices. This slot will focus on the fundamental understanding of strain in perovskites and how intrinsic or externally applied strain can dictate the performance of perovskite devices, now having realistic prospects of penetrating in the market in their flexible form.

The second part will be dedicated to “strain in quantum-confined nanostructures including quantum dots, Van der Waals materials for optoelectronics and nanowires”. The recent discovery of quantum light emission and direct bandgap in semiconductor transition metal dichalcogenide monolayers have triggered intensive research of these materials as promising candidates for flexible and ultra-compact advanced quantum technologies in photonics. In another note, nanowires are filamentary crystals that offer the possibility to apply a higher level of strain, thereby allowing fine-tuning of their electrico-optical and thermal properties since the reduction of dimensions increases the fracture stress limits. In the context of this session, we will discuss the possibility of controlling the optoelectronic properties of semiconductor quantum dots in nanomembranes, nanowires and VdW materials in a large range owing to their extraordinary stretchability, strategies that offer exciting perspectives.

This symposium will be highly interdisciplinary, bridging the fields of materials science, chemistry, physics and engineering. We will discuss cutting-edge progress on materials processing, device fabrication and characterisation in the macro, micro and nanoscale, from both theoretical and experimental perspectives. We expect to incentivise the development of novel practical systems that base their working principles on strain management.

Thursday, 03 September 2020

Zoom host, Dolores Martín.

9:30-10:10 *Using pressure to study the impact of the electron-phonon interaction on the band structure of bulk and nano-crystalline hybrid perovskites*. **Alejandro R. Goñi (invited)**.

10:10-10:30 *Controlled epitaxial growth of hybrid halide perovskites*. **Sheng Xu**.

10:30-10:50 *Photoflexoelectricity in Halide Perovskites*. **Gustau Catalan**, Longlong Shu.

10:50-11:10 *Strain and chemi-structural mechanisms when FAPbI3 perovskite matches the PbS QDs lattice*. **Sofia Masi,** Carlos Echeverría-Arrondo, K. M. Muhammed Salim, David F. Macias-Pinilla, Juan I. Climente, Iván Mora-Seró.

11:10-11:30 *Segregation of defects at grain boundaries in halide perovskites*. **Ji-Sang Park**.

11:30-11:50 *Strain engineering in perovskite solar cells and its impacts on carrier dynamics*. **Qi Cheng**.

11:50-12:10 *Transient behavior of nanomechanical domains in triple cation perovskite films studied by atomic force microscopy*. **Ioanna Mela**, Chetan Poudela, Miguel Anaya, Géraud Delport, Kyle Frohna, Samuel D. Strank and Clemens Kaminski.

12:10-12:30 *Permanent Lattice Compression of Lead-Halide Perovskite for Persistently Enhanced Optoelectronic Properties*. **Ahmed Abdelhady**.

Special session Thursday Afternoon

Zoom host, Dolores Martín. Pre-recorded talks and poster videos on Youtube.

Pre-recorded talks

1. Fracturing of polycrystalline MoS2 nanofilms. **Marianna Sledzinska**, G. Jumbert, M. Placidi, A. Arrighi, P. Xiao, F. Alzina and C.M. Sotomayor Torres.

2. Mechanical properties of atomically-thin chromium trihalides. **Fernando Cantos-Prieto**, Alexey Falin, Martin Alliati, Dong Qian, Rui Zhang, Tao Tao, Elton J. G. Santos, Lu Hua Li, Efrén Navarro-Moratalla.

Posters

1. Compression increases the activation barrier for phase segregation in mixed-halide perovskites. **Loreta A. Muscarella**, Eline M. Hutter, Francesca Wittmann, Young Won Woo, Young-Kwang Jung, Jan Versluis, Aron Walsh, Huib J. Bakker, Bruno Ehrler.

2. Structural and optical properties of mixed-valence gold halide perovskite, Cs2Au2I6: Emerging lead-free material for photovoltaic applications. **Bhawna,** Mrinmoy Roy, Aftab Alam, M. Aslam.

3. Femtosecond laser cutting of PMN-PT substrates for the fabrication of piezoelectric actuator devices. **Sandra Stroj**, Giovanni Piredda, Dorian Ziss, Julian Stangl, Rinaldo Trotta, Javier Martín‐Sánchez, Armando Rastelli.

4. Reconstructive versus displacive-like transition in FeF3. **Alvaro Lobato**, Miguel Recio-Poo, Alberto Otero-de-la-Roza, Miguel A. Salvadó, and J. Manuel Recio.

5. Correlative microscopy techniques for probing subgrain structure and composition in halide perovskites. **Affan N. Iqbal**, Tiarnan Doherty, Elizabeth Tennyson,Yu-Hsien Chiang, Miguel Anaya, Simone Ruggeri, Duncan Johnstone, Samuel Stranks.

6. Influence of strain on the thermoelectric properties of Bi/TiO2 core/shell nanowires. **Maximilian Kockert**, R. Mitdank, H. Moon, J. Kim, A. Mogilatenko, S. H. Moosavi, M. Kroener, P. Woias, W. Lee, S. F. Fischer.

Friday, 04 September 2020

Zoom host: Dolores Martín.

9:30-10:10 *Illuminating novel functionalities of TMD nanostructures with electron microscopy*. **Sonia Conesa-Boj (invited)**.

10:10-10:50 *Site-controlled and energy-tuneable single-photon sources in two-dimensional materials*. **Rinaldo Trotta (invited)**, M. Savaresi, A. Martínez-Suárez, D. Tedeschi, V. M. G. Suarez, P. Alonso-González, J. Martín-Sánchez.

10:50-11:10 *Strain-engineered single photon sources with atomically thin crystals*. **Schneider Christian**.

11:10-11:30 *2D straintronics*. **Andrés Castellanos**, Patricia Gant, Peng Huang, David Pérez de Lara, Dan Guo, Riccardo Frisenda.

11:30-11:50 *Strain tuning of the anisotropy in the optoelectronic properties of the two-dimensional transition metal trichalcogenide TiS3*. **Jose Angel Silva Guillen**, Enric Canadell, Pablo Ordejón, Francisco Guinea, Rafael Roldán.

11:50-12:10 *Strain engineering in hBN-encapsulated graphene*. **Lujun Wang**, Blesson Varghese, Andreas Baumgartner, Simon Zihlmann, Peter Makk, Jan Overbeck, David Indolese1, Kenji Watanabe, Takashi Taniguchi, and Christian Schönenberger.

12:10-12:30 *Direct and converse flexoelectricity: the effect of strain gradients and electric field gradients on nanoscale electromechanical responses*. **Neus Domingo**.