# Seminar of the Department of Low-dimensional Systems

We invite you to the seminar presented by the guest of the US Embassy in Prague:

## Dr. Frank W. DelRio

*from*

**Material Measurement Laboratory, National Institute of Standards and Technology, Boulder, CO, USA**

*entitled*

## Silicon as a mechanical material

Date **5th June, 2017**
Time **10:30**
Location **room 108, J. Heyrovsky Inst. Of Physical Chemistry, Prague**

The abstract of the talk is attached. For those who want to meet the speaker individually, please contact martin.kalbac@jh-inst.cas.cz. We are looking forward to meet you at the talk.

J. Heyrovský Institute of Physical Chemistry

# Silicon as a mechanical material

Dr. Frank W. DelRio
Material Measurement Laboratory, NIST, Boulder, CO, USA

In 1982, Kurt Petersen at IBM Research Laboratory wrote the seminal review paper entitled Silicon as a Mechanical Material. In this paper, Petersen asserted that "silicon, in conjunction with its conventional role as an electronic material, and taking advantage of an already advanced microfabrication technology, can also be exploited as a high-precision high-strength high-reliability mechanical material, especially applicable wherever miniaturized mechanical devices and components must be integrated or interfaced with electronics". This single statement was one of the driving forces behind the development of microelectromechanical systems (MEMS) and later nanoelectromechanical systems (NEMS), which have since been incorporated into several industrial applications such as inkjet printers, accelerometers, gyroscopes, microphones, and digital micromirror devices. However, the progression from idea to products has taken significant time and resources, in large part due to uncertain mechanical reliability. In particular, reliability issues related to the deformation and fracture of MEMS and NEMS silicon components have become increasingly important given continued reductions in critical feature sizes coupled with recent escalations in both device actuation forces and harsh usage conditions.

In this talk, key points from Petersen's paper and subsequent studies on the mechanical properties of silicon are reviewed. This is followed by more detailed descriptions of three recent NIST studies on the deformation and fracture of MEMS and NEMS silicon components, with a particular emphasis on the rationale behind the test method and its ability to answer important yet open questions in the literature. Finally, the results from these studies and others are used to reconcile several of Petersen's original statements, and also to generate one of the most comprehensive review papers to date on the strength of MEMS and NEMS silicon components.