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Live investigations of thin film deposition by advanced scanning tunneling microscopy

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Scanning Tunneling Microscopy (STM) is a very appealing technique for atomic-scale investigations of the deposition and growth of thin films. The microscopic insights that can be acquired with STM are highly relevant in view of the ever more stringent requirements to e.g. structural quality and smoothness imposed on thin films in practical applications. This is illustrated by two examples that both involve live observations, i.e. movies, of the evolution of thin films during deposition and growth.

Graphene can be synthesized by chemical vapor deposition (CVD) on metal surfaces. This process requires hot substrates, with temperatures up to e.g. 1000°C. This is in direct conflict with the vulnerability of scanning probe microscopes to high temperatures and their extreme sensitivity to thermal drift. In this talk, I will demonstrate how we have constructed dedicated STM instrumentation that can cope with these harsh conditions, which enables us to follow the CVD-based growth of graphene in great detail [1]. Examples will be given for the growth of graphene on Rh(111) [2] and on Ir(111) [3]. The results of this work contribute to recipes for the growth of high-quality graphene.

The second example concerns the direct atom-by-atom deposition or erosion of surfaces under the influence of atom beams and ion beams [4]. This type of experiments requires a line of sight between the sources of atoms and ions and the region on the surface that is periodically imaged by the STM tip, which is achieved by virtue of a dedicated instrument design. The result will be illustrated by live observations of atom-by-atom growth and impact-by-impact erosion. They contribute to our understanding of the performance of multilayer mirrors that are used as optical elements for extreme ultraviolet light and soft x-rays.

[1] M. J. Rost et al., Rev. Sci. Instrum. 76, 053710 (2005).
[2] G. Dong et al., ACS Nano 7, 7028 (2013).
[3] D.W. van Baarle et al., to be published.
[4] V. Fokkema et al., to be published.

SHORT BIO

Joost Frenken is the Director of the Advanced Research Center for Nanolithography (ARCNL) in Amsterdam and a professor of Physics at both universities in Amsterdam (UvA and VU) and at Leiden University.

Frenken obtained his PhD degree (with highest honors) in Physics in 1996 at Utrecht University, based on work carried out at FOM-Institute AMOLF. After a postdoctoral stay at the Max-Planck-Institut für Strömungsforschung in Göttingen and a research stay at IBM Research in Yorktown Heights, he became a group leader at AMOLF. Frenken was appointed professor at Leiden University in 1994 and moved to Leiden's Kamerlingh Onnes Laboratory in 1996. Frenken has combined his research with several organizational tasks, for example as Scientific Director of the Dutch, national SmartMix consortium on Nano-Imaging under Industrial Conditions and Program Director of several national research programs. In 2014, Frenken moved to Amsterdam to head ARCNL.

Frenken's scientific expertise is in the structure, diffusion, chemical reactions, phase transitions and friction phenomena at surfaces and interfaces, investigated with advanced, often home-built instruments. His achievements have been recognized in several research awards and by his membership of the Netherlands Royal Academy of Sciences (KNAW). Frenken has (co)-initiated two companies, Leiden Probe Microscopy BV and Applied Nanolayers BV.