Reinke Research Group

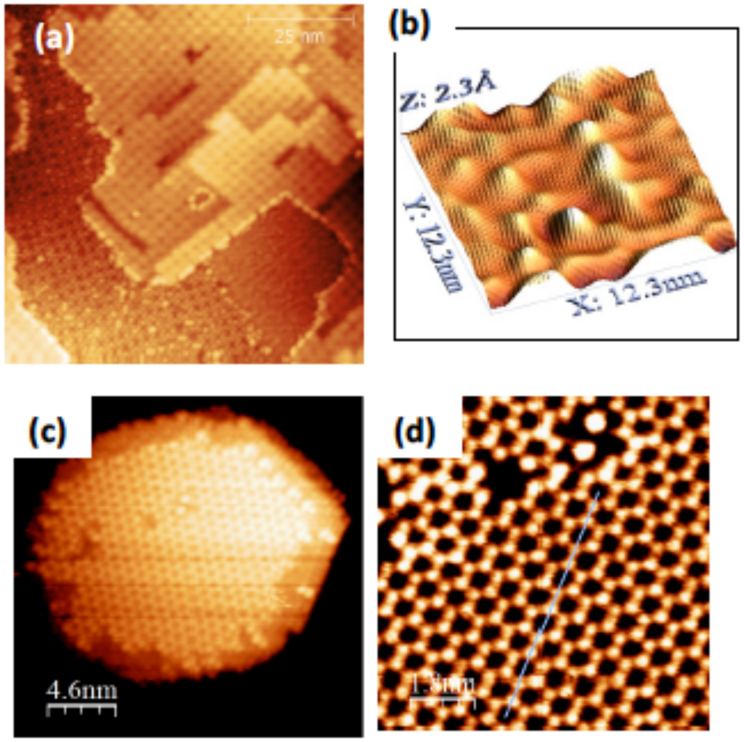

Figure 1: (a) NiO thin film on Ni 14%Cr alloy surface, (b) Graphene layer on a Cu-substrate – the deformation of the graphene layer is caused by C_{60} molecules inserted between Cu and graphene, (c) $MoSi_2$ crystallite with a silicene top layer, (d) high resolution image of the silicene layer with atomic resolution.

Our group is interested in nanostructures and surface reactions, specifically oxidation and corrosion reactions at the atomic scale. We use surface science methods, such as scanning probe microscopy (mostly STM) and photoelectron spectroscopy to study electronic and geometric structure and properties and find new routes for growth and manipulation of nanomaterials. Our work aims to advance the design of nanomaterials, which is critical in many areas of application. In the last few years we have started to integrate more and more tools of data analytics in our work, which helps to unlock the full information content of our microscopy images. This comprehensive approach will ultimatly lead us to control nanostructure properties from the bottom up using our in-depth understanding of processes and reactions at the atomic scale. We therefore study a wide range of materials, where surface and nanoscale interactions drive functionality.

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"Engineer materials, alloys and surfaces that perform in predictable ways at the nanoscale."

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- Study the atomic level reactions which drive *oxidation of NiCr superalloys*. This will lead to new pathways for the selective formation of the protective chromia over Nickel-oxide (NiO). Figure 1(a) is an example of an ultrathin NiO layer grown on an alloy made of Ni with 12at% Cr. The structure of the oxide layer is related to the interaction between oxide and alloy, which enables us to extract details about the geometric and electronic structure of the interface. At the same time we also investigate the oxidation of another technically important material – molybdenum silicides.

- Investigation of the *ordering of molecular layers made of coronene molecules on highly corrugated surfaces with variable electronic structure*. Molecular layers are important in many different applications such as solar cells and molecular electronics, and the stacking of the molecules is closely related to their functionality. For example, efficiency pf charge transfer which is a key element in solar cell performance, is modified quite dramatically if molecules are stacked like pancakes or parallel lamellae. We look specifically at molecule arrangement on highly corrugated surfaces, which is poorly understood but reflects a realistic scenario in their technical use.

- Development and manipulation of *2D materials* is an ongoing effort in our research. The figure includes two recent examples: (b) is the manipulation of graphene by intercalation of molecules at the graphene-Cu interfaces, and (c) and (d) show our most recent discovery, namely a silicene layer which naturally forms on $MoSi_2$ surfaces. Both materials, graphene and silicene, are critical materials for ultrafast, and low-energy electronic devices. In addition, we plan to pursue the chemistry at graphene-metal interfaces in the near future to establish graphene as a protective coating.

RECENT RESEARCH DEVELOPMENTS

- Discovered new method for the synthesis of silicene
- Manipulation of molecule electronic structure by metal-molecule reactions
- Unraveled atomic level mechanisms for NiCr superalloy oxidation
- Developed method for recovery of carbide catalytic activity after oxidation

RECENT GRANTS

- NSF – DMR Ceramics: "Investigation of the Oxidation of Stoichiometric and Carbon Rich Tungsten Surfaces" -PI
- NSF – Chemistry: "Nanosphere Synthesis and the Impact of Curvature on Molecule Adsorption" - PI
- ONR-MURI - "Understanding Atomic Scale Structure in Four Dimensions to Design and Control Corrosion Resistant Alloys" – Co-PI
- DURIP-ONR: "Acquisition of an X-ray Photoelectron Spectrometer for In-situ Experiments to advance Corrosion Studies, Surface and Interface Engineering" -PI
- Strategic Investment Fund – UVa – Multifunctional Materials Integration MMI – Co-PI

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