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Corrosion of Materials Across Multiple Length Scales

U.S. ARMY RDECOM

ARL open campus

S&T Campaign: Materials Research

Tier 2 Manufacturing Science, Processing & Sustainment

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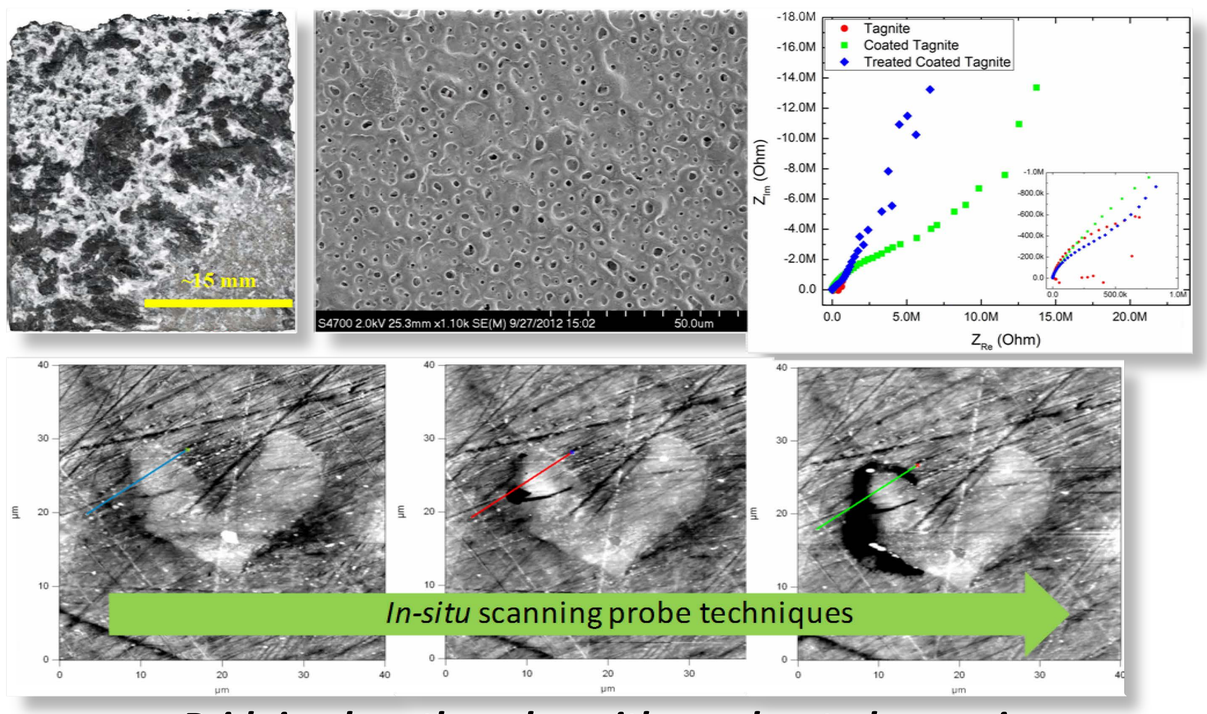
Research Objective

- **To understand fundamental corrosion mechanisms of materials.**
- **By utilizing new techniques at multiple length scales to develop a comprehensive understanding of materials degradation processes, effective mitigation strategies are being developed.**



Bridging length scales with accelerated corrosion, electrochemistry, and in-situ measurement

Challenges

- "Stainless" High-Strength, Lightweight Magnesium Alloys
- Environmentally Friendly Corrosion Inhibitors
- Robust, bondable, active thin film coatings
- **Specific Challenges-** robust super-hydrophobic surfaces, active non-toxic corrosion inhibitors (NO Cr^{6+}!), identify localized defect sites and chemical and morphological differences across heterogeneous oxide surfaces.

Complementary Expertise Sought

- Electrochemical and electro-analytical expertise (SECM, EIS, CV, advanced techniques)
- Atom Probe Tomography

Future work-

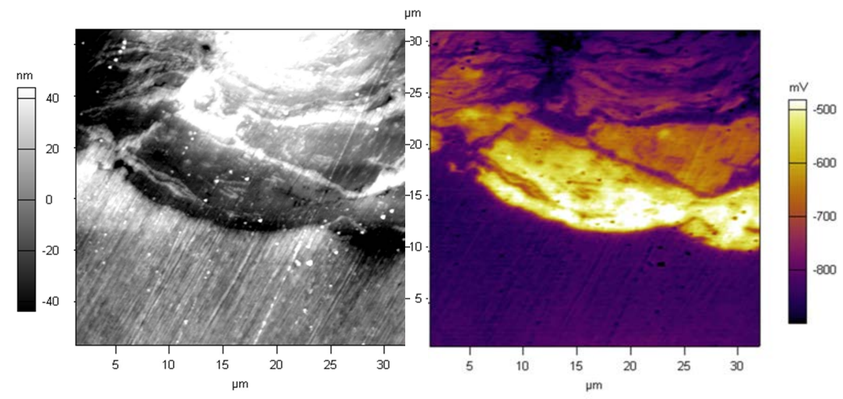
- Advanced electro-synthetic methodologies for new coatings on Mg and Al surfaces.
- Understand the nature of oxide surfaces on homogeneous and heterogeneous lightweight alloys.
- Kinetic and thermodynamic modeling of corrosion

References:

1) Kristen S. Williams, Joseph P. Labukas, Victor Rodriguez-Santiago, and Jan W. Andzelm (2014) Firstprinciples modeling of water dissociation on Mg(0001) and development of a Mg surface Pourbaix diagram. Corrosion In-Press. **doi:** http://dx.doi.org/10.5006/1322.
2) Kenneth E. Strawhecker and Daniel P. Cole., Morphological and Local Mechanical Surface Characterization of Ballistic Fibers via AFM. Journal of Applied Polymer Science, 2014. doi: 10.1002/APP.40880
3) Joseph P. Labukas and Kenneth E. Strawhecker. Scanning Probe Investigation of Pitting Corrosion on Aluminum 5083 H131 . Army Research laboratory Technical Report # 6925. May 2014.
4) Joseph P. Labukas and Victor Rodriguez-Santiago. Bondable Fluorinated Barrier Coatings. U.S. Patent application filed . ARL 14-14.

ARL Facilities and Capabilities

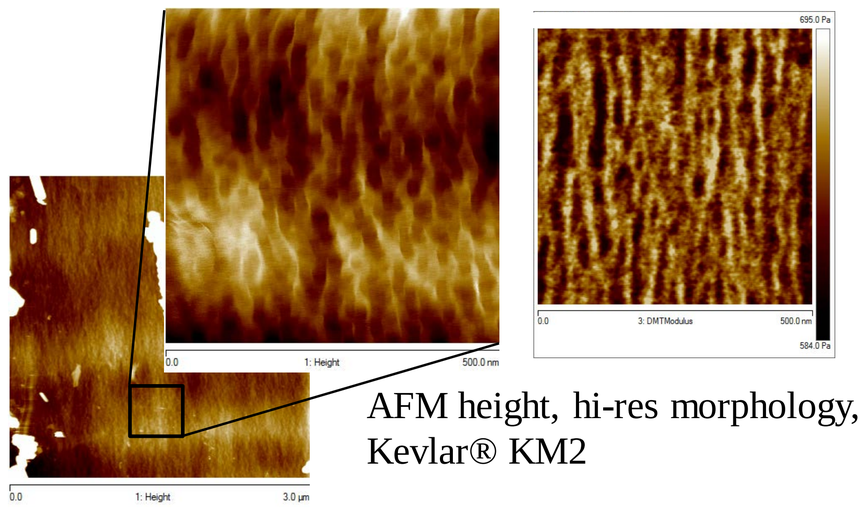
- **World-class scanning probe laboratories**



AFM height (left) and Scanning Kelvin Probe (right) images of Cu surface refined using Fe spheres and SMAT process. Cu substrate shown in lower ½ of image, Fe/Cu interface at top ½

Asylum Research an Oxford Instruments company

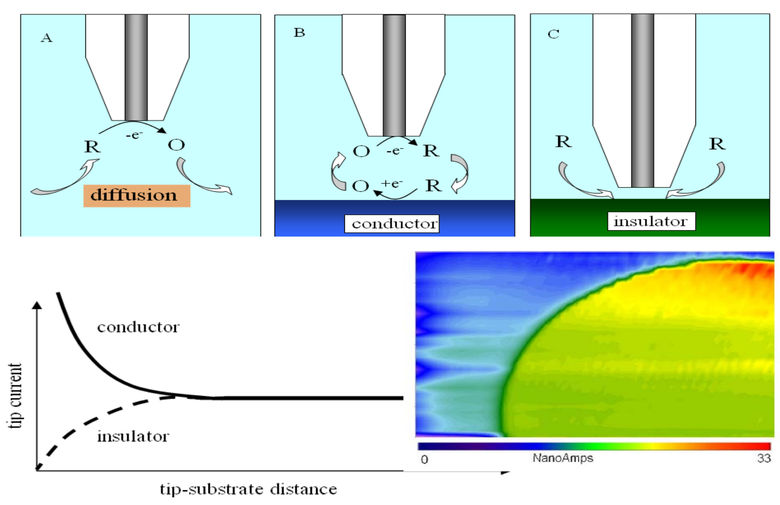
MFP-3D AND Cypher AFMs with microwave, SKP, photothermal excitation, modulus mapping, and electrical techniques



AFM height, hi-res morphology, and modulus mapping of Kevlar® KM2

Veeco BRUKER

Dimension 3100 AND Multimode 8 AFMs with peak force, conductive, MFM, and STM modes.

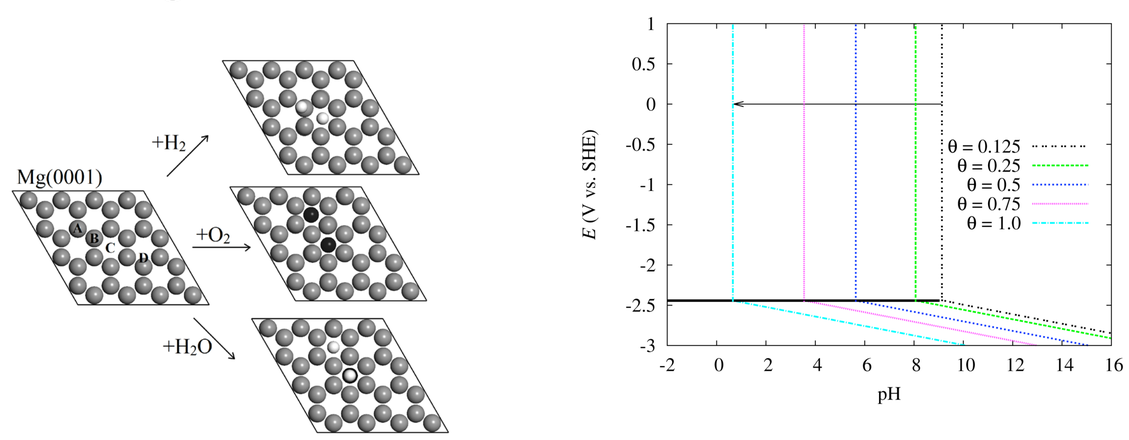


Scanning Electrochemical Microscopy (SECM) for surface reactivity and kinetics

Princeton Applied Research

VersaSTAT 3, 3F, 4, and PARSTAT 4000

- **Modeling for Corrosion**



- **ARL Expertise-** Electrochemistry, thin film deposition, RBS, plasma modification, surface chemistry, corrosion, AFM
- **Early Findings-** SECM sensitive to surface prep. and choice of mediator, AFM can be disruptive to surface.

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