WILDE LAB.

Dynamics of Water and Ice on Cold Surfaces

Department of Fundamental Engineering
Social Collaboration Program: Frost Protection Science

Surface Physical Chemistry
https://www.iis.u-tokyo.ac.jp/en/research/department_center/frost-protection-science/

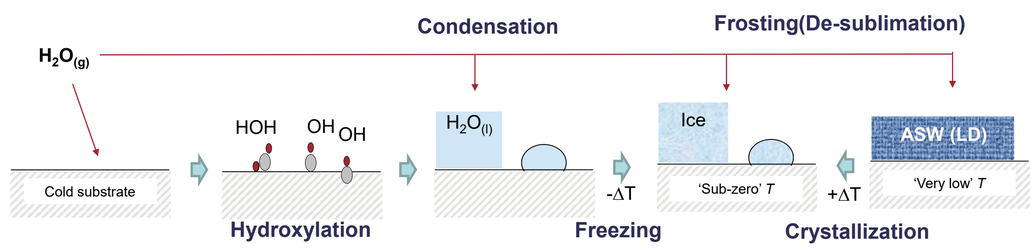
Molecular Perspective on Frost Formation on Cold Surfaces

Frost formation – the growth of ice films from water vapor on cold surfaces – a daily life phenomenon that seriously obstructs heat transfer at refrigerated surfaces, is still not well understood at the molecular level. This laboratory employs (ultra)-high vacuum experimental techniques to reveal fundamental molecular interactions and (de-)sublimation dynamics in interfacial water and ice films on solid surfaces, especially of well-defined oxides as model systems for naturally oxidized metals. We clarify how the chemical constitution, atomic structure, and macroscopic wetting properties of the surface influence interfacial water-ice phase transitions and the crystallization kinetics of amorphous solid water films prepared at cryogenic temperatures.

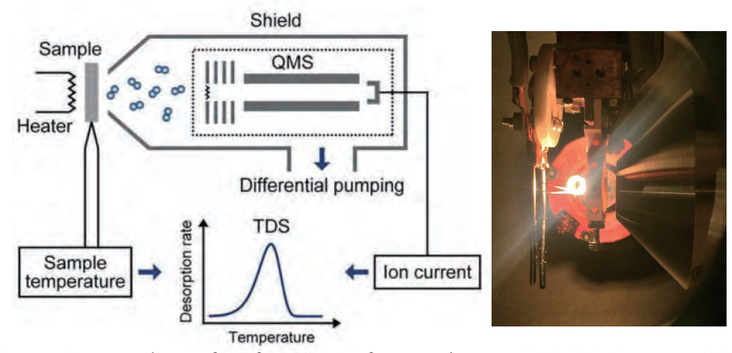
◆ **Key Experimental Techniques & Information Gain**

- ✓ *Low Energy Electron Diffraction (LEED):* → Atomic Surface Structure (Periodicity) of Substrate and Thin Ice Films
- ✓ *Thermal Desorption Spectroscopy (TDS)*: → H_2O Sublimation/De-sublimation Kinetics ▪ Energies of Desorption and Intermolecular Interactions between H_2O molecules in Interfacial Water/Ice Layers
- ✓ IsoThermal Desorption Analysis (ITDA): → Crystallization Kinetics of Amorphous Solid Water Films
- ✓ *Nuclear Reaction Analysis (NRA)*: → Hydrogen Depth Profiling with Nanometer Resolution ▪ Quantification of Surface Hydroxyl (OH) Coverages ▪ Thermal Stability, Depth Distribution and Diffusion of (O)H in Surface Oxide Layers

H_2O Adsorption, Hydroxylation, Condensation Freezing and Frosting on Cold Surfaces

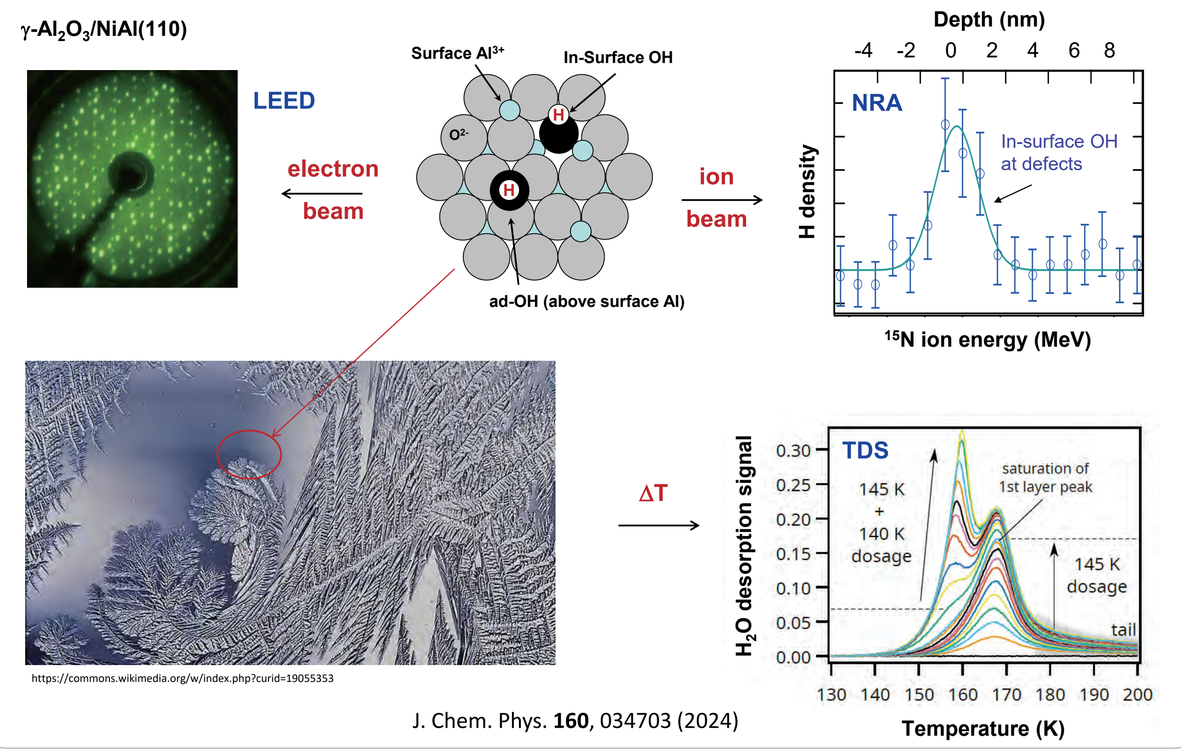


Thermal Desorption Spectroscopy (TDS)



S. Ogura, Compendium of Surface & Interface Analysis, p. 719-724, Springer, 2018.

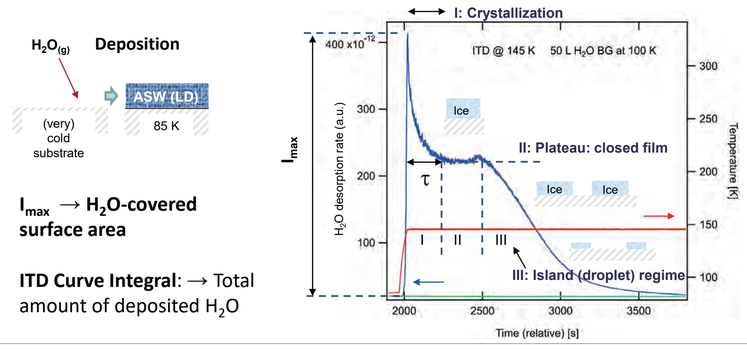
Structure and Dynamics of interfacial H_2O/ice films on well-defined Al_2O_3 surfaces



https://commons.wikimedia.org/w/index.php?curid=19055353

J. Chem. Phys. **160**, 034703 (2024)

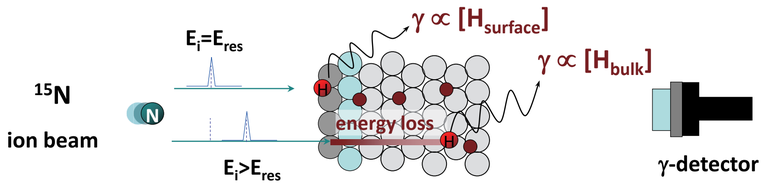
Isothermal Desorption Analysis (ITDA)



- I_{max} → H_2O-covered surface area
- **ITD Curve Integral**: → Total amount of deposited H_2O

Resonant Nuclear Reaction Analysis (NRA)

J. Vis. Expt. **109**, e53452 (2016) Surf. Sci. Rep. **69**, 196 (2014)



$^{15}N(6.385\ MeV) + {}^{1}H \rightarrow {}^{12}C + \alpha + \gamma(4.43\ MeV)$