Epitaxial growth of superconducting thin aluminum films on InAs for topological quantum computing

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MBE grown material based upon hybrid semiconductor-superconductor has generated a lot of interest recently due to the possibility that it allows for the emergence of Majorana Zero Modes (MZM) which may offer topological protection for quantum computing. [1]

Relevant material platforms for MZM based devices include semiconductors with high spin-orbit coupling such as InAs on GaSb, and InAs on InP which are coupled to a s-wave superconductor that shows 2e periodicity in a closed system. Thin aluminum films, ~7nm, meet these requirements and have been shown to have a high critical in-plane magnetic field. Additionally, the aluminum has remarkable epitaxial relationship with InAs allowing for atomic ordering of Al (111) parallel to InAs (100). [2]

The growth of thin epitaxial aluminum is extremely sensitive to temperature. Deposition at T>0°C causes many grains to form or the film to ball up. Depositing thin Al films at T~77°K shows good morphology but not the requisite crystallinity. Thin films, <10nm, deposited within the good temperature window show structure which matches the semiconductor and has two distinct in-plane orientations, both (111) in plane (Fig. 1). This Al-InAs hybrid system shows an induced gap >200μeV. Here we present optimization and characterization of superconducting Al layers on MZM devices.

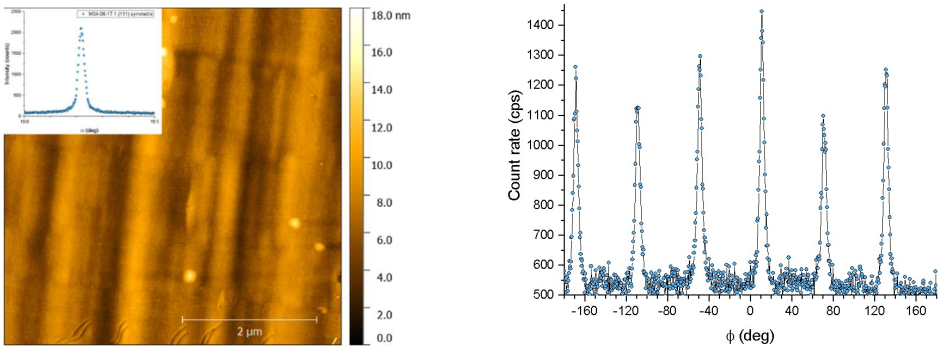

Figure 1, L) an AFM image showing Al film on semiconductor with a corresponding symmetric omega scan showing a well-defined Al (111) peak inset. R) a phi scan of (-1-11) revealing two domain orientations of nearly equal distribution.

[1] S. Das Sarma, et al., npj Quantum Information (2015). doi:10.1038/npjqi.2015.1
[2] P. Krogstrup, et al., Nature Materials (2015). doi:10.1038/nmat4176

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