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Ultra-thin Lattice Matched Cr_xMo_{1-x}/MgO Multilayers

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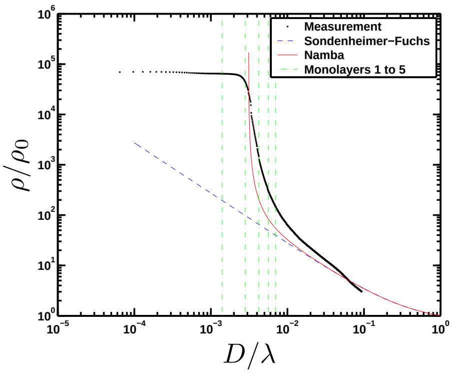
Introduction

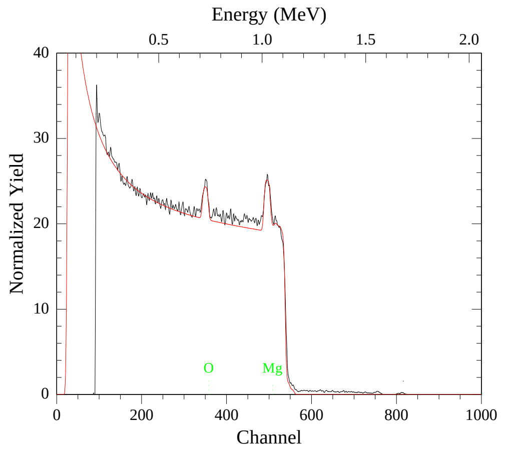
- Lattice matched heteroepitaxial films were prepared in a magnetron sputtering discharge
- Cr_xMo_{1-x} thin films were grown on MgO (100) using a DC discharge [Meyvantsson et al., 2004]
- An MgO over-layer was grown on top by reactive sputtering in a pulsed bipolar discharge
- The resistivity of the Cr_xMo_{1-x} films was measured in situ using a four-point probe
- Ex situ Rutherford backscattering (RBS), X-ray diffraction (XRD) and low angle reflectometry (XRR) measurements were used to determine the film composition, structure, thickness, surface and interface roughness
- Reflection high energy electron diffraction (RHEED) confirmed epitaxial growth

Resistivity versus thickness



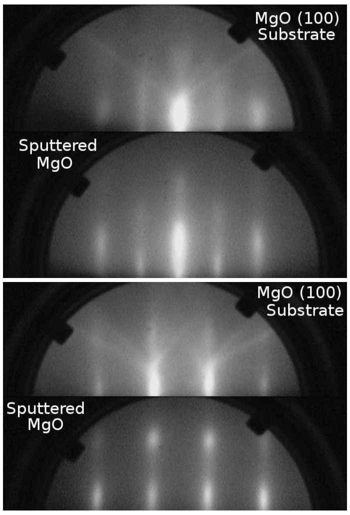
- The Cr_xMo_{1-x} alloy composition is chosen such that the inter-atomic distance along the $< 011 >$ direction approximates the lattice constant of MgO
- A 99% lattice match can be achieved for $0.56 \leq x \leq 0.8$[Chambers, 2000]
- In situ growth curves for $Cr_{0.63}Mo_{0.37}$ show a coalescence thickness of less than two monolayers indicating layer by layer growth

Stoichiometry



- Rutherford Back Scattering (RBS) measurements of MgO grown on Si confirm that the film grows in the correct stoichiometry (1:1)
- Similarly RBS was used to confirm the $Cr_{0.63}Mo_{0.37}$ stoichiometry

RHEED



- The figures show RHEED scans of an MgO substrate and an MgO film grown on top of a CrMo film
- The film has the same orientation and lattice parameters as the substrate and is epitaxially grown

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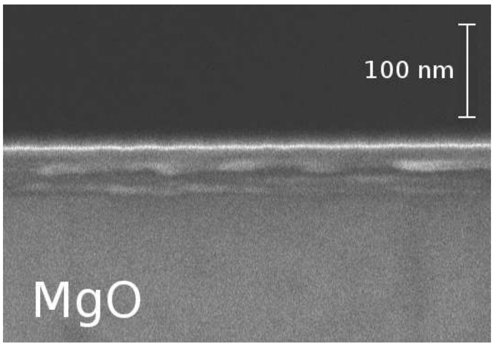
Metal-insulator-metal (MIM)



- A full metal-insulator-metal (MIM) structure MIM was created by growing another CrMo film
- A Scanning Electron Microscope (SEM) image of a MIM structure with film thicknesses 200Å CrMo, 40Å MgO and 200Å CrMo

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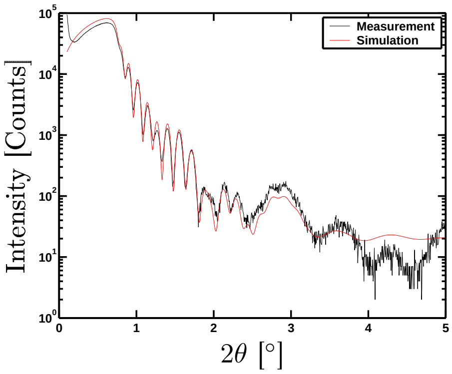
X-ray Reflectometry (XRR)



- Estimates for film thicknesses and interface roughness was obtained from XRR measurements
- The figure shows a MIM structure with film thicknesses 50Å CrMo, 80Å MgO and 420Å CrMo
- The interface roughness of the films are between 3-5Å and surface roughness is 15Å

Summary

- Heteroepitaxial growth of a MIM structure was confirmed
- RHEED, XRR, XRD, RBS and resistance measurements were used to characterize the growth mechanisms

Acknowledgments

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References

[Chambers, 2000] Chambers, S. A. (2000). Epitaxial growth and properties of thin oxide films. *Surface Science Reports*, 39:105–180.

[Meyvantsson et al., 2004] Meyvantsson, I., Olafsson, S., Johnsen, K., and Gudmundsson, J. T. (2004). Preparation and characterization of magnetron sputtered, ultra-thin $Cr_{0.63}Mo_{0.37}$ films on MgO. *Journal of Vacuum Science and Technology A*, 22:1636–1639.