Microstructural Characterization of Ni MEMS

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Introduction
The microstructure of the Ti/Ni bridge structure of the RF MEMS switches is being analyzed to provide inputs and validation for atomistic and micromechanical computer simulations.

Methods
The Ti/Ni film is composed of a 100 nm of sputtered Ti seed layer, a 30 nm e-beam evaporated Ni layer, and a ~2.8 thick electroplated Ni layer. Cross-sectional samples were prepared for TEM by the FIB in-situ liftout technique using an FEI XT Nova NanoLab Dual Beam FIB/SEM. TEM images were obtained using an FEI Tecnai T20 TEM and an FEI Titan 80/300 field emission TEM.

Results
An initial FIB investigation showed that the bridge thickness and grain structure are uniform within each switch as well as from switch to switch. Therefore, a TEM sample taken from any location is a reasonable representation of the Ti/Ni bridge structure in general.

Grain Size Characterization
The Ti/Ni film has a V-shaped, columnar microstructure, which is a product of competitive grain growth during film deposition [2]. The average in-plane grain size \(d\) increases as a function of film thickness \(h\), following the “power law” model [3], \(d = h^{0.58}\), where the value of \(0.58\) is ~0.58 for the Ni film under study here.

Phase I: Test the sensitivity of micromechanical simulations using experimentally measured values of average grain size ± standard deviation.

Phase II: If simulations are sensitive to grain size, a more sophisticated TEM analysis will be done to produce grain size PDFs (i.e., grain size histograms at range of film thicknesses \(h\), as done by Spiecker et al. [4]), e.g.:

Texture Characterization
The Ni film exhibits \{200\} and \{111\} texture, which sharpens with increasing film thickness.

Future Work
The grain size and crystallographic texture will be further quantified as required to properly inform simulation efforts. Specifically, a new TEM technique will be developed to determine the relationship between grain size and crystallographic texture as a function of film thickness within a single polycrystalline film specimen.

Key Collaborators
Atomistic Simulations: Alejandro Strachan & Hojin Kim, Purdue University, School of Materials Engineering
Micromechanical Simulations: Marisol Koslowski & Abigail Hunter, Purdue University, School of Mechanical Engineering

References