I would like to thank DU’s Partners in Scholarship program for financing my research this summer.

Our laboratory uses a form of Plasma Vapor Deposition (PVD) known as magnetron sputtering to make metallic films with layers that are only a few atoms thick.

We deposit onto wafers of silicon which have an oxidized top layer, in order to increase surface smoothness and reduce the interaction between the wafer and the sample.

This exact procedure (and a very similar machine) is used by electronics manufacturers like Intel and AMD to make their high end computer processor chips.

For this experiment, we used Cobalt for layers with in-plane magnetization, and an Iron-Nickel alloy called Permalloy for layers with normal magnetization.

In metals, e−'s transmit heat energy through the material. Hotter e−'s have higher velocity and demand more space.

Thus a temperature gradient results in different charge density on either side of the sample – an electric potential (ΔV hot to cold).

In conductive thin films, the Spin Hall effect still applies. When a voltage is applied, the top of the sample becomes magnetized:

- This effect has an inverse (ISHE): when aligned e−'s are transmitted vertically through a thin film, an in-plane potential is observed.

Spin Rotation (SR):
- In a magnetic field, e−'s will rotate or precess around the axis of the field:
- This behavior can be explained by Quantum Mechanics principle known as spin-transfer torque.
- As this precession occurs, the e−'s eventually aligns with the axis of the magnetic field.

λSR from Spin Rotation:
- For λSR at Pt thickness between 3 to 4nm:
- This first part of this curve corresponds to the FMR component of spin damping – until about 2nm of Pt is deposited, e−'s can pass through the layer without interacting.
- After a complete Pt layer is deposited, the subsequent damping is much weaker. This corresponds to the bulk component of spin damping (see the curve fit below).

ΔV vs Δl:

References and Acknowledgements:
I would like to thank DU’s Partners in Scholarship program for funding my research this summer.