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Prediction of spin band widths in Co/Al nanolaminates

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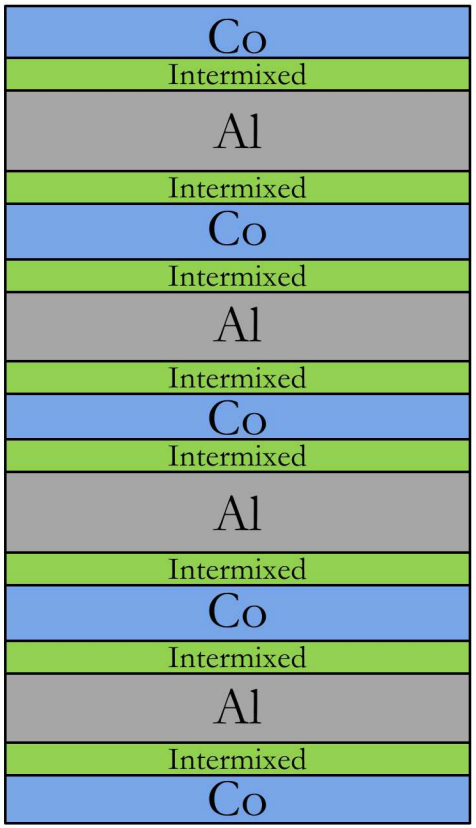
Self-propagating reactions in Co/Al nanolaminates

33 nm Bilayer, 7.5μm total thickness, 5.7 m/s
50 μs per frame, played at 5 fps



Self-propagating reactions in Co/Al nanolaminates

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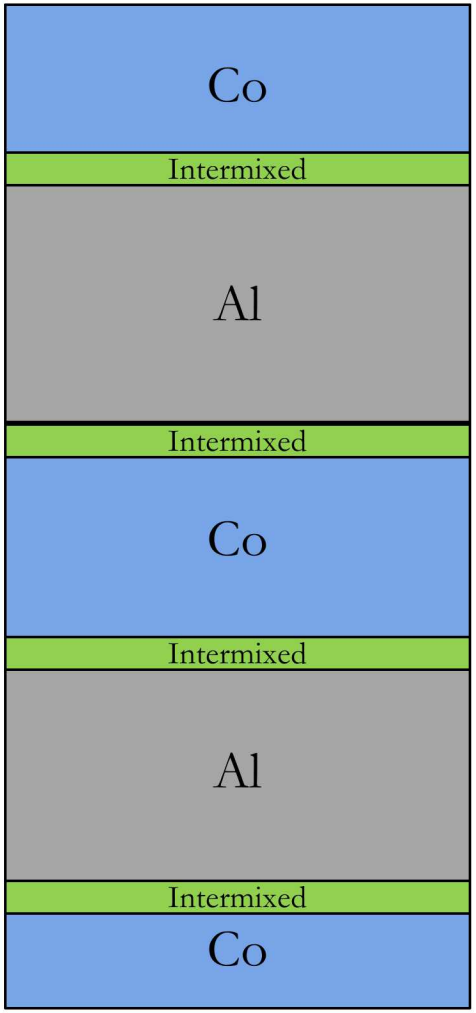
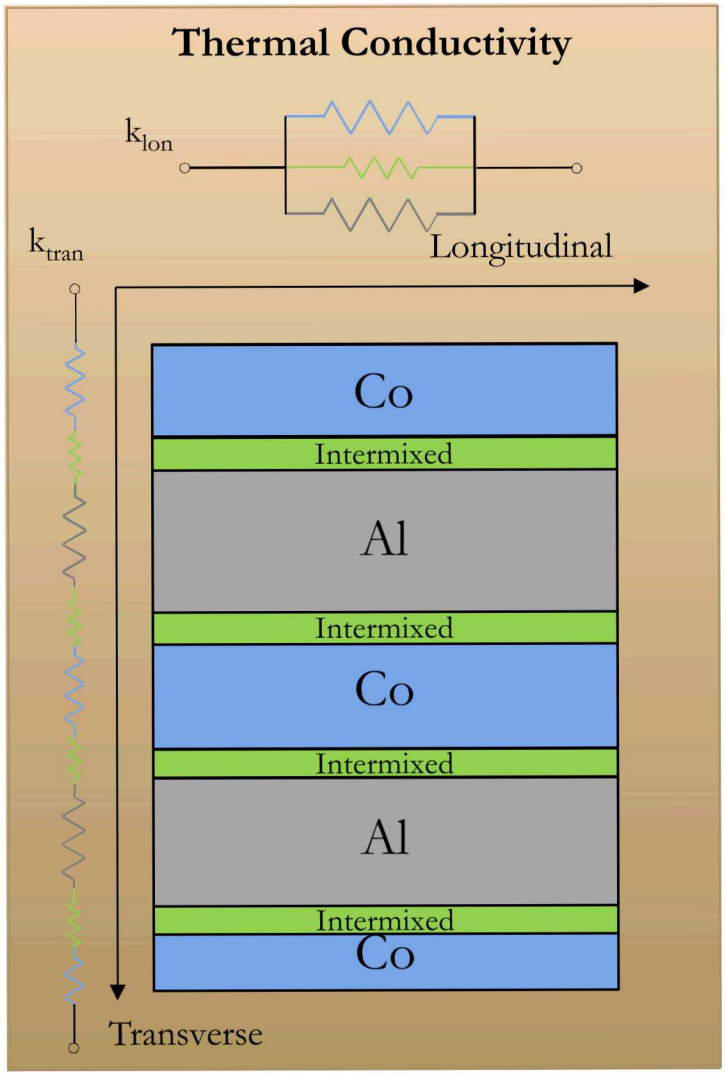


75 nm Bilayer, 7.5μm total thickness, 2 m/s
50 μs per frame, played at 5 fps

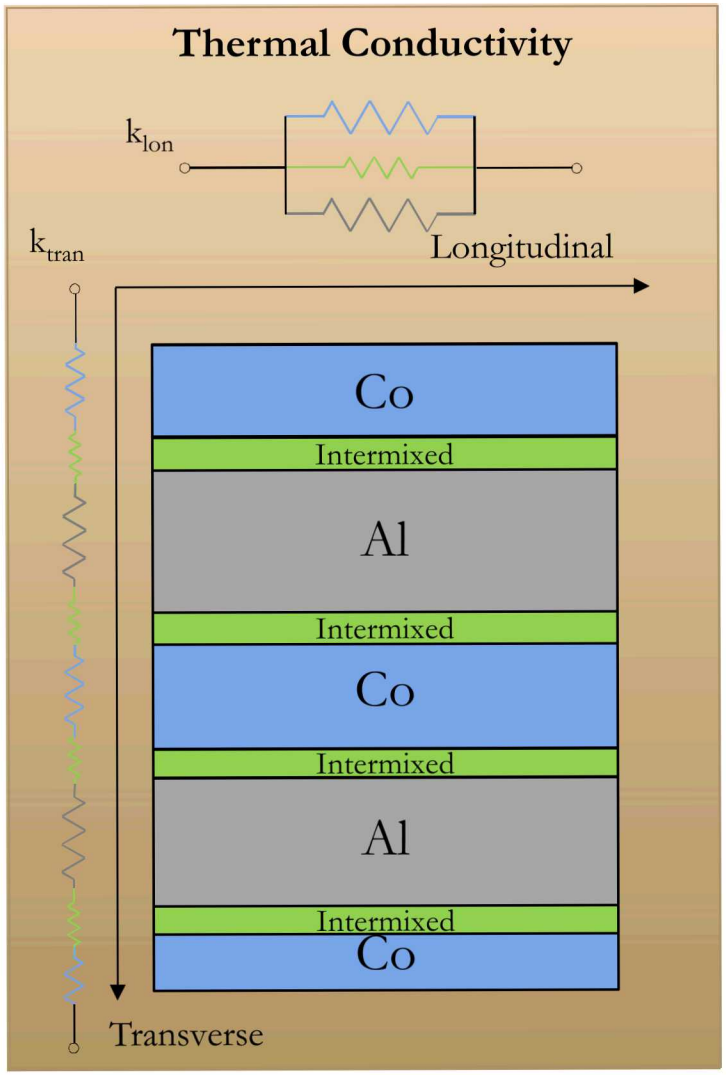
1 mm

Analytical model of propagation

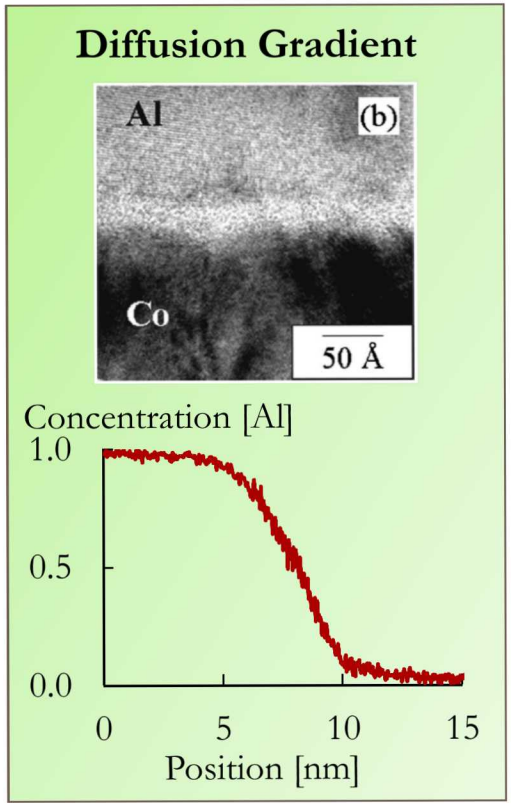


$$v_x^2 = \left(\sum_{n=odd} \frac{k_n^2}{\alpha_n^2}\right)^{-1} \frac{4\lambda_x^2 R T_f^2 D}{E_A \lambda_y (T_{ad} - T_0)} exp\left(\frac{-E_A}{R T_f}\right)$$

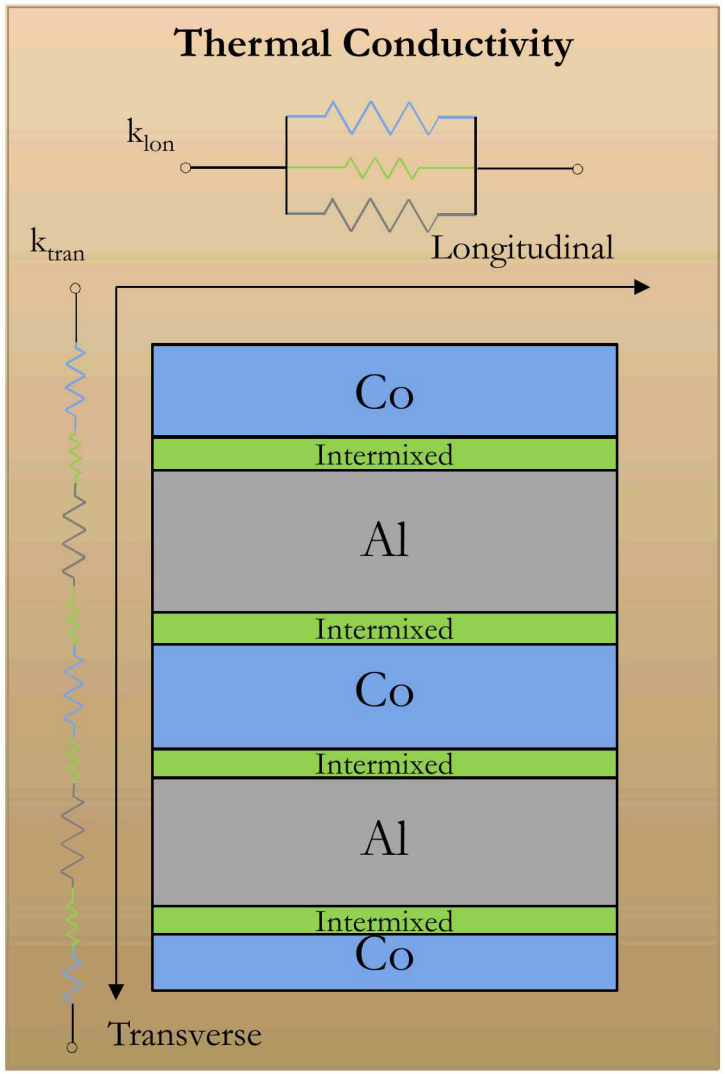
Analytical model of propagation



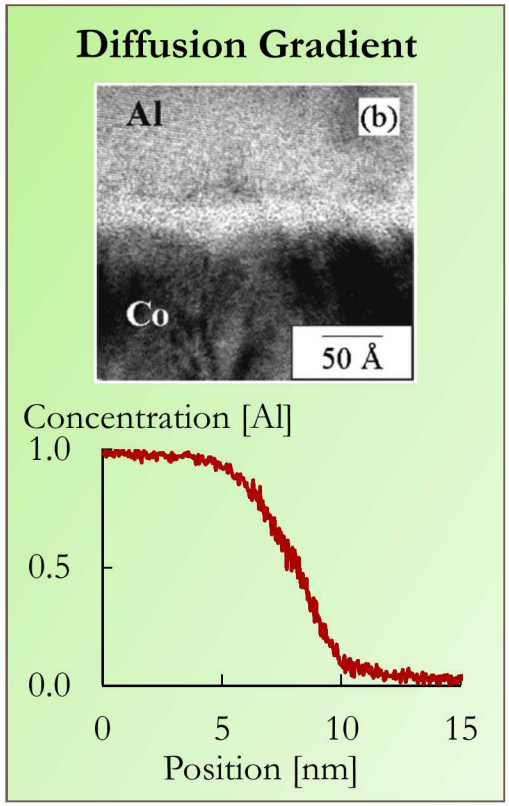
$$v_x^2 = \left(\sum_{n=odd} \frac{k_n^2}{\alpha_n^2}\right)^{-1} \frac{4\lambda_x^2 R T_f^2 D}{E_A \lambda_y (T_{ad} - T_0)} exp\left(\frac{-E_A}{RT_f}\right)$$

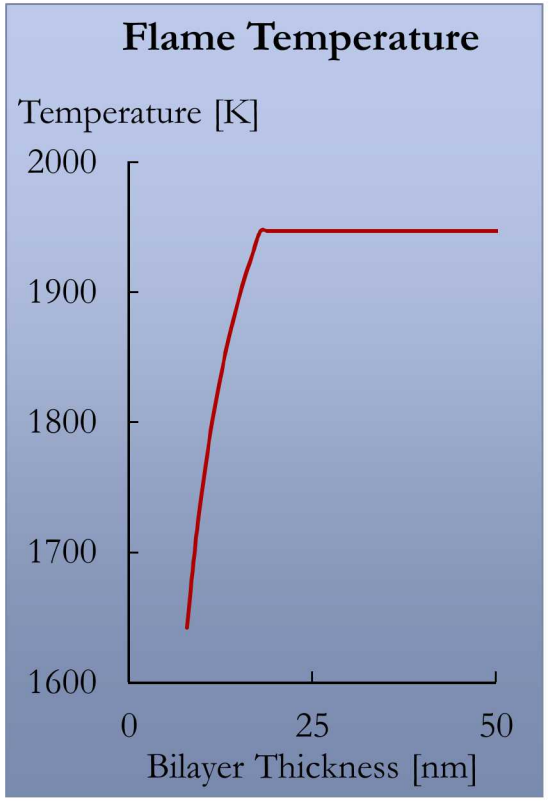


Analytical model of propagation

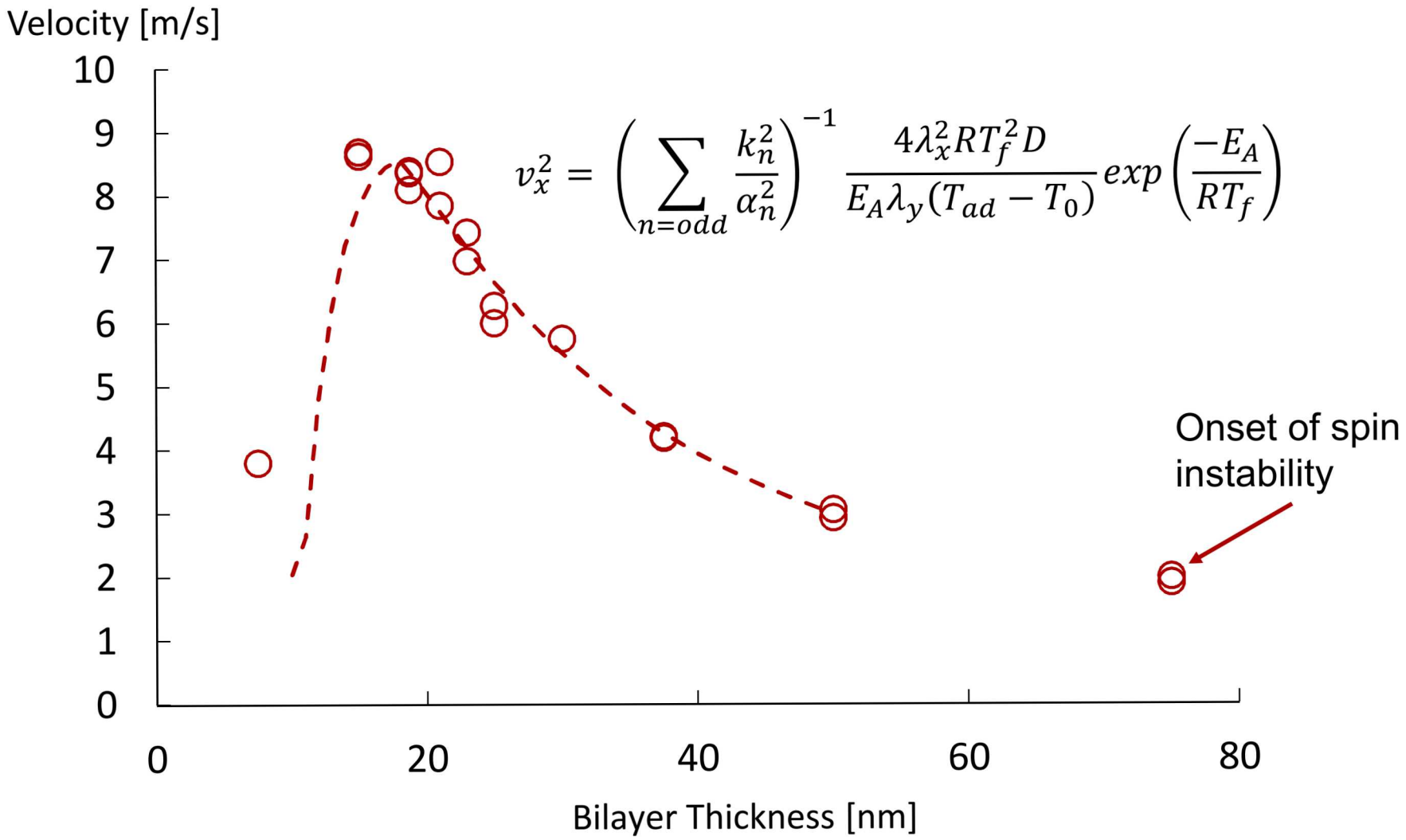


$$v_x^2 = \left(\sum_{n=odd} \frac{k_n^2}{\alpha_n^2}\right)^{-1} \frac{4\lambda_x^2 R T_f^2 D}{E_A \lambda_y (T_{ad} - T_0)} exp\left(\frac{-E_A}{R T_f}\right)$$





Analytical fit to stable propagation



Analytical fit extended to threshold bilayer design for the onset of spin

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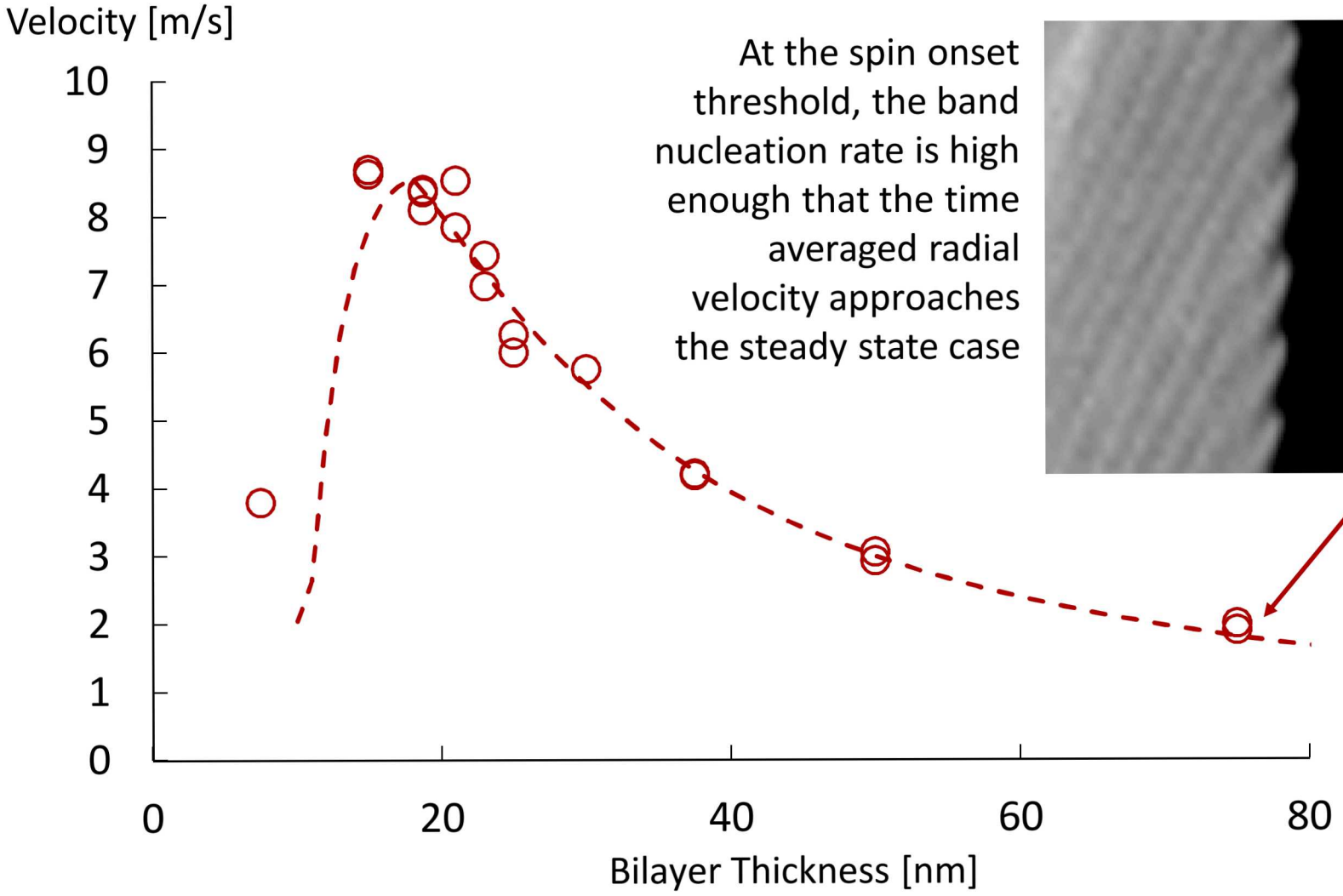
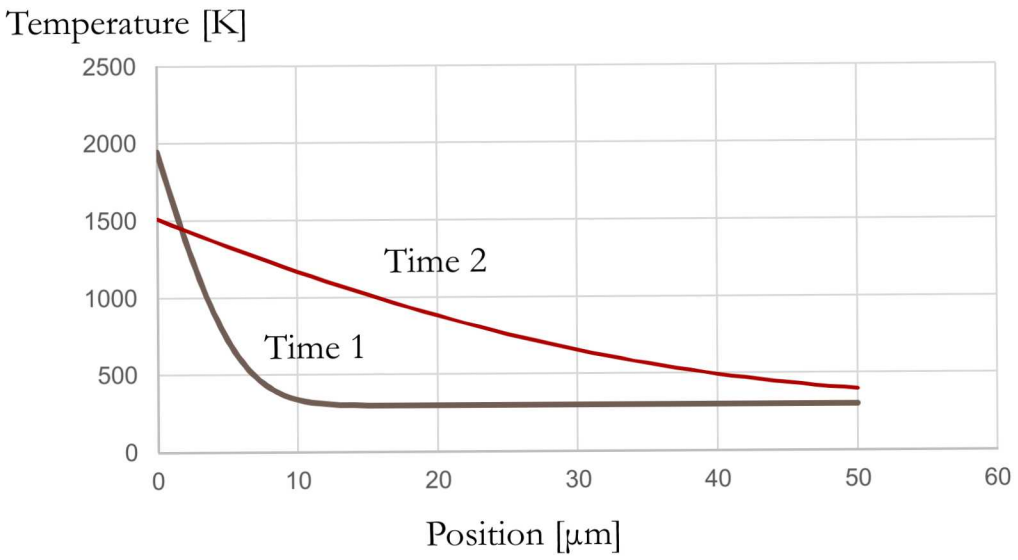
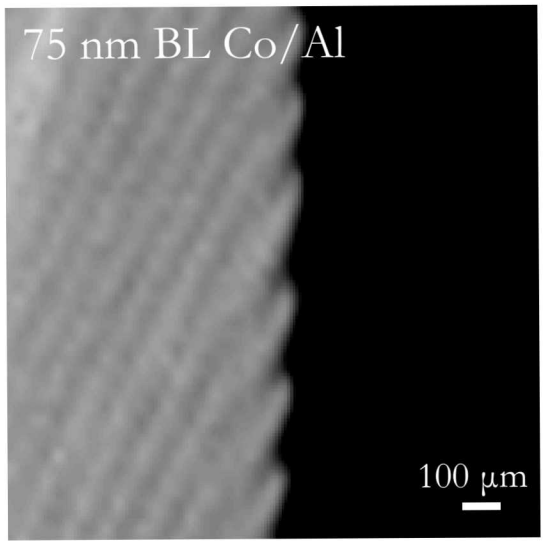
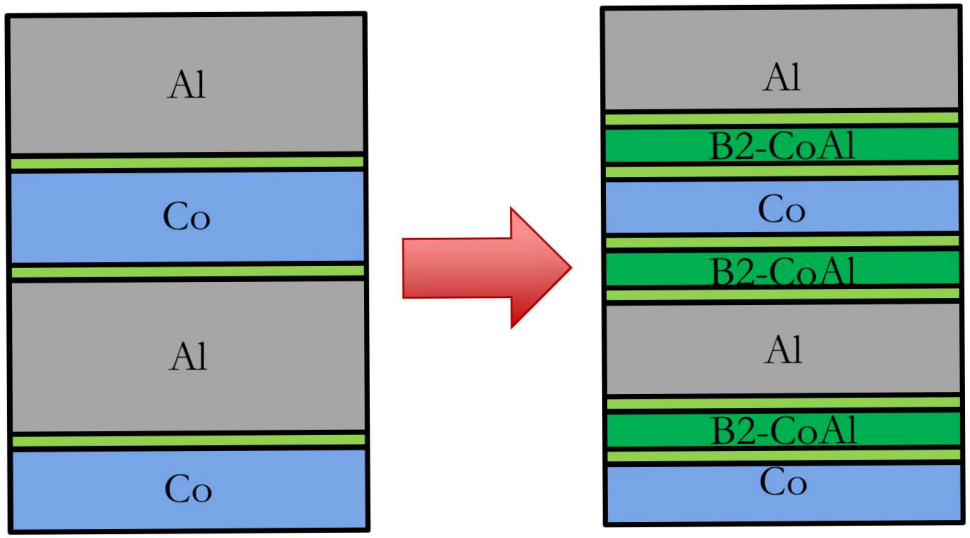
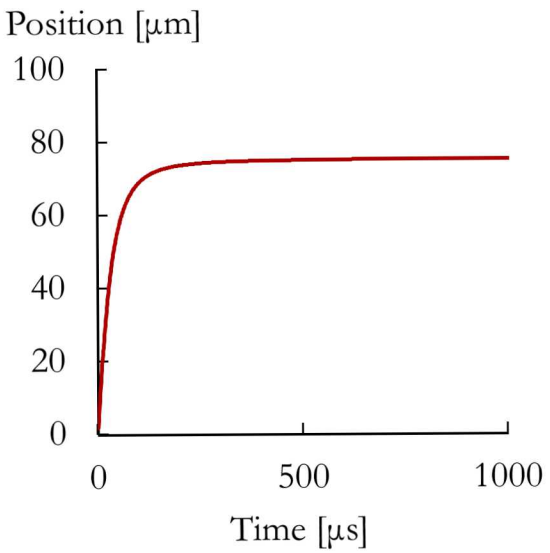


Toy model for spin band quench

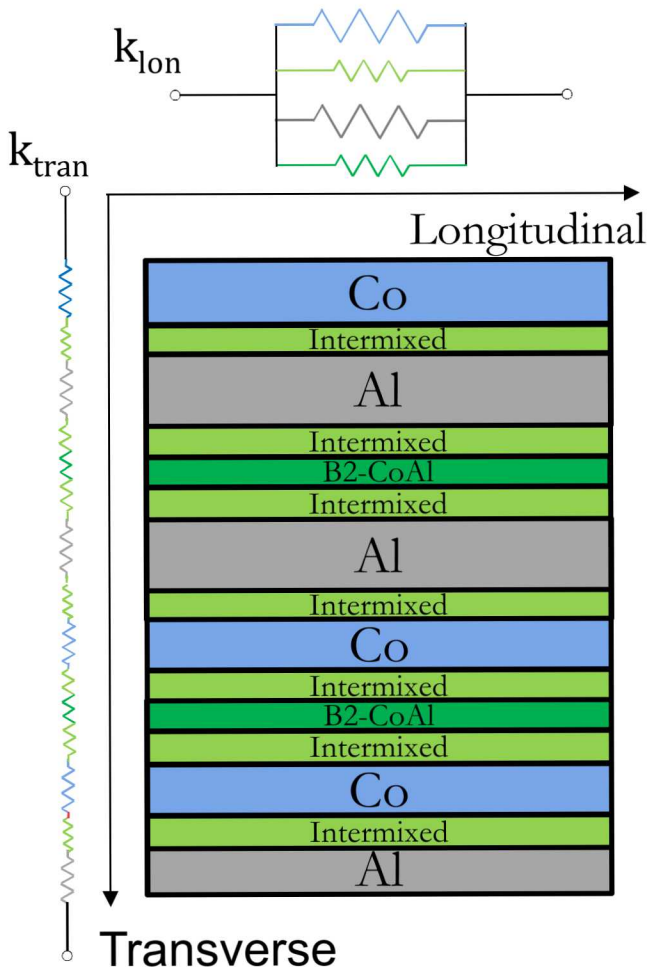


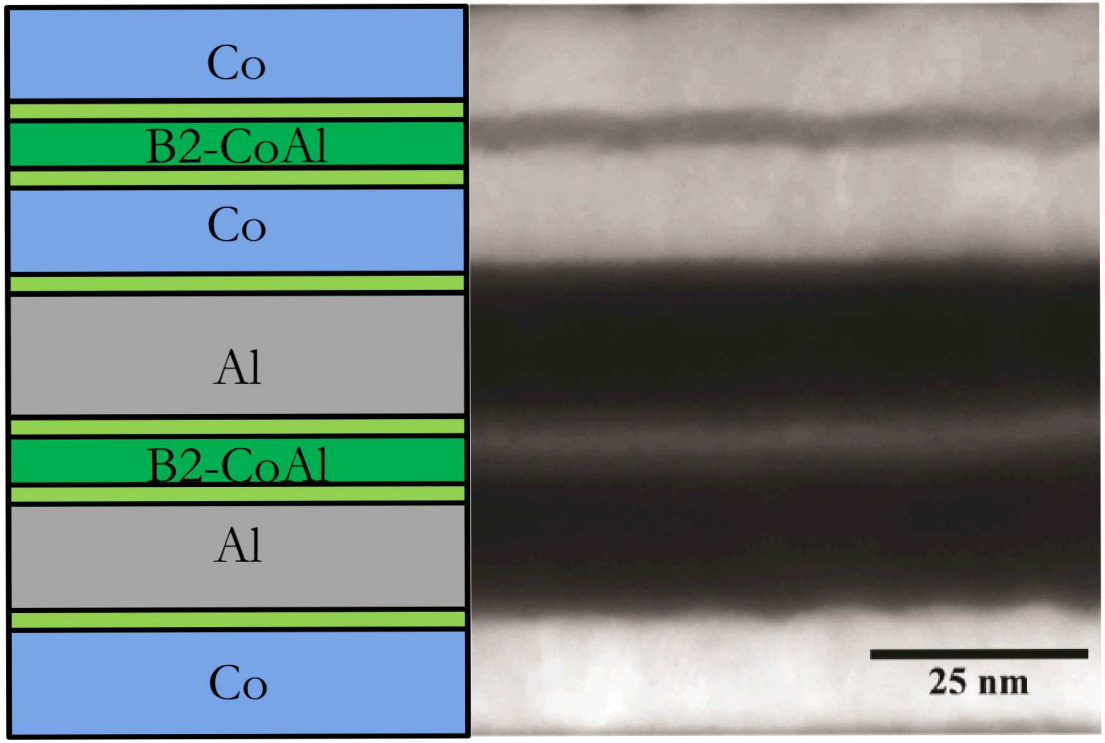






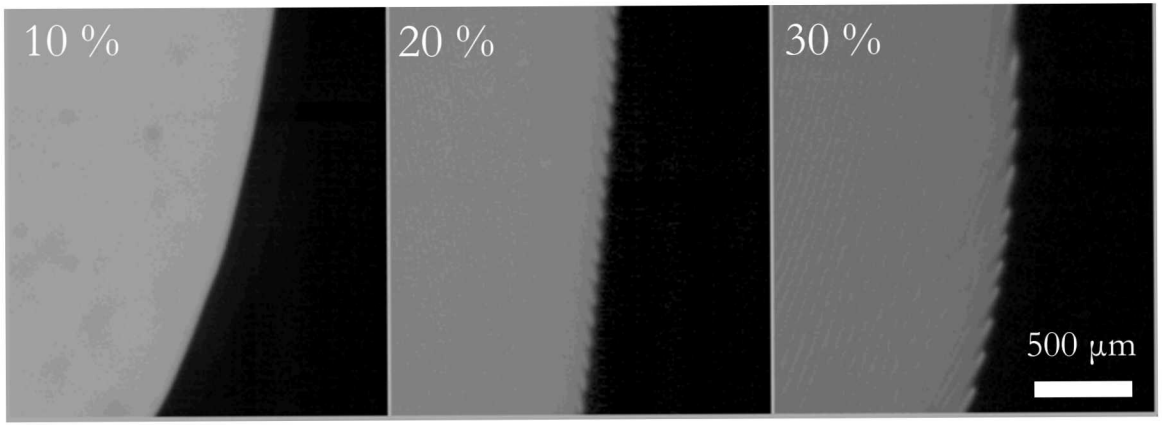
Co/Al nanolaminates with diluent



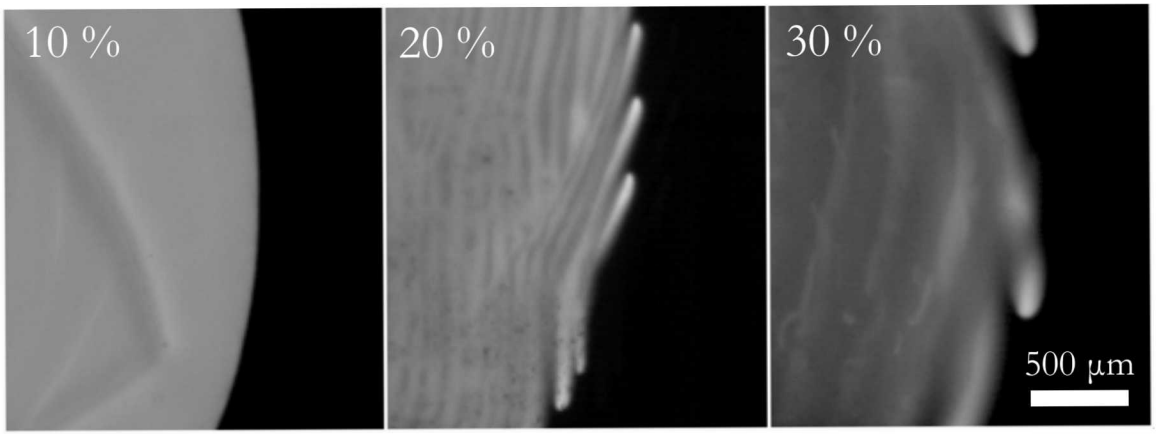


Spin induced via dilution

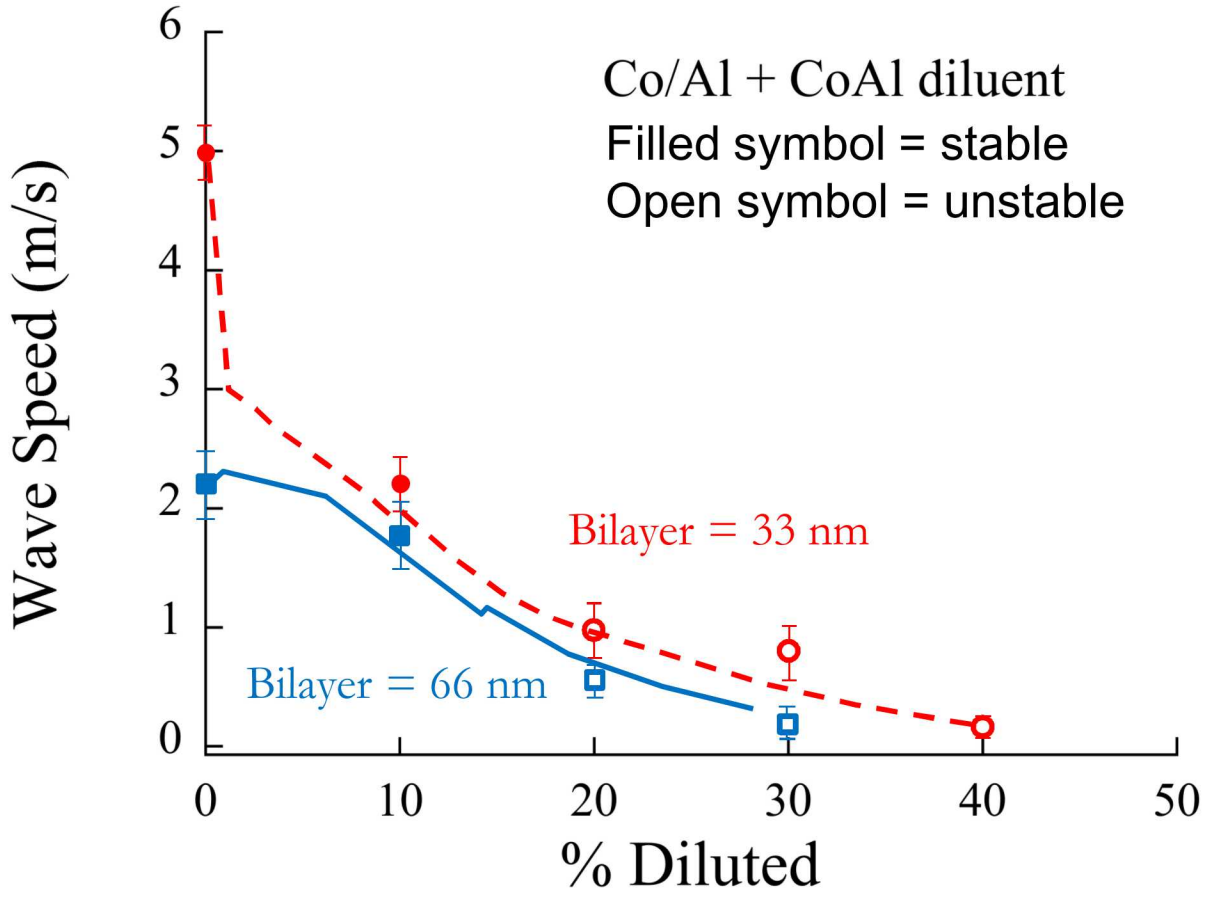
(a) 33 nm Bilayer



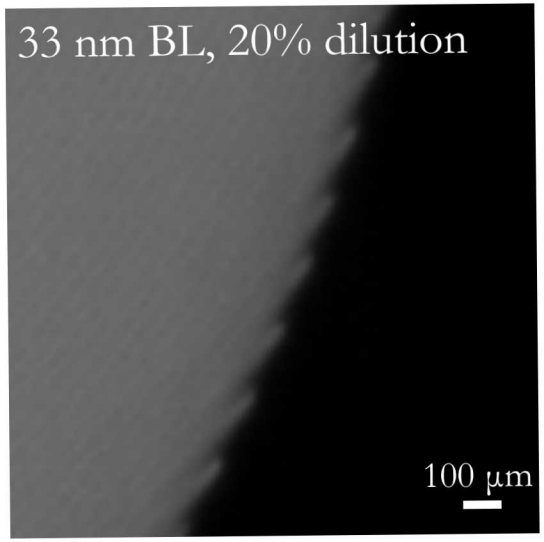
(b) 66 nm Bilayer

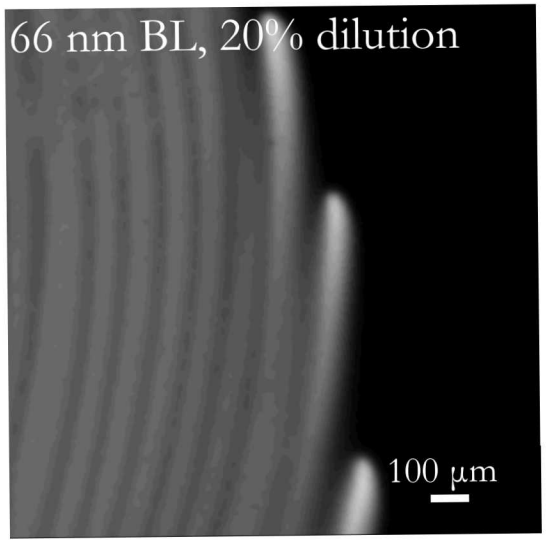


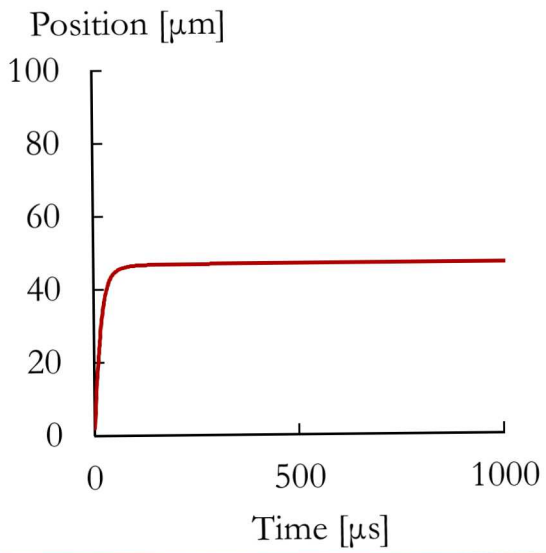
Radial velocity of diluted Co/Al

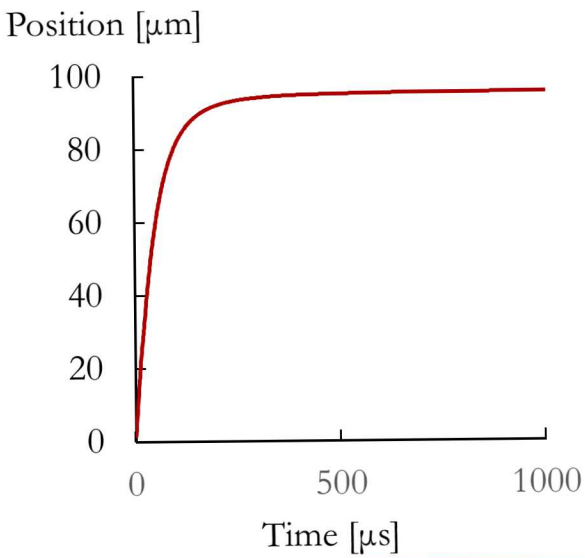


Model fits to spin band widths induced by diluent layers

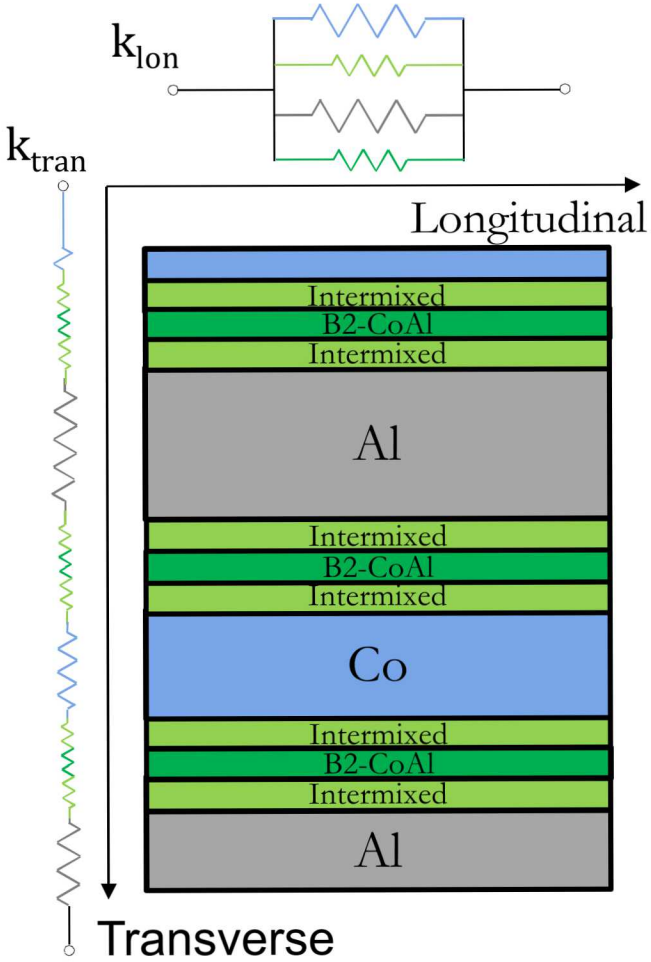


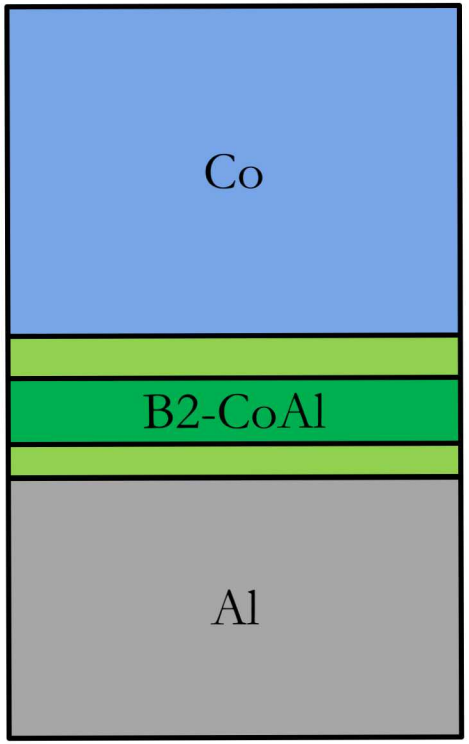


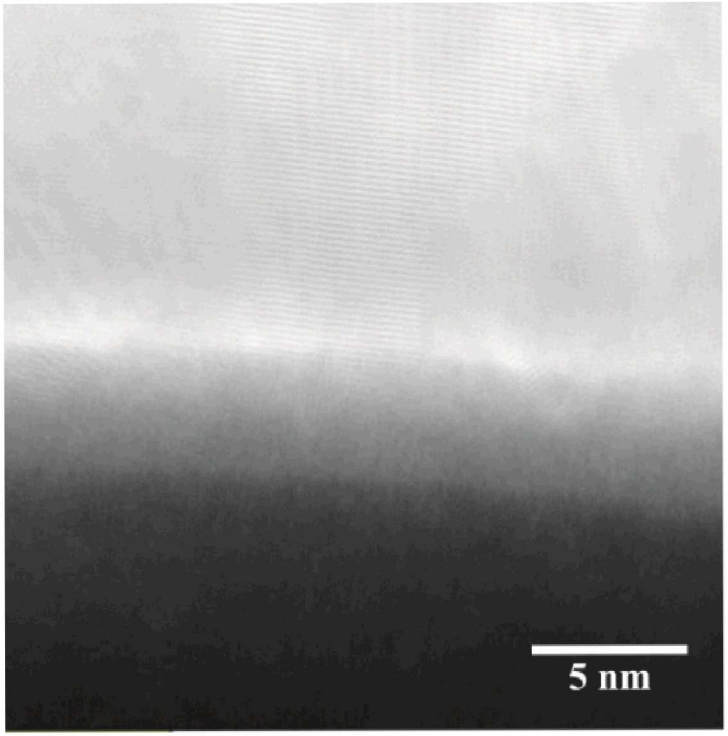




Co/Al nanolaminates with diffusion barriers







Spin induced via diffusion barriers

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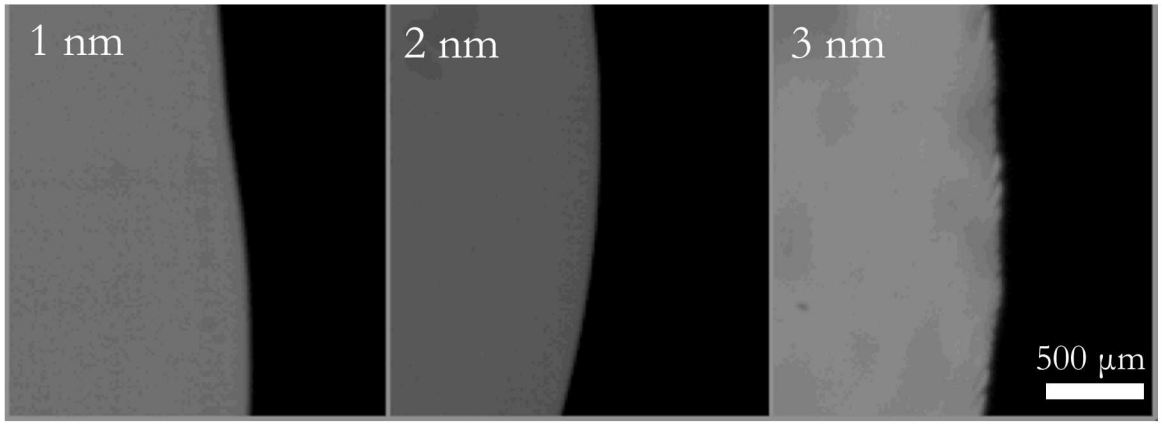
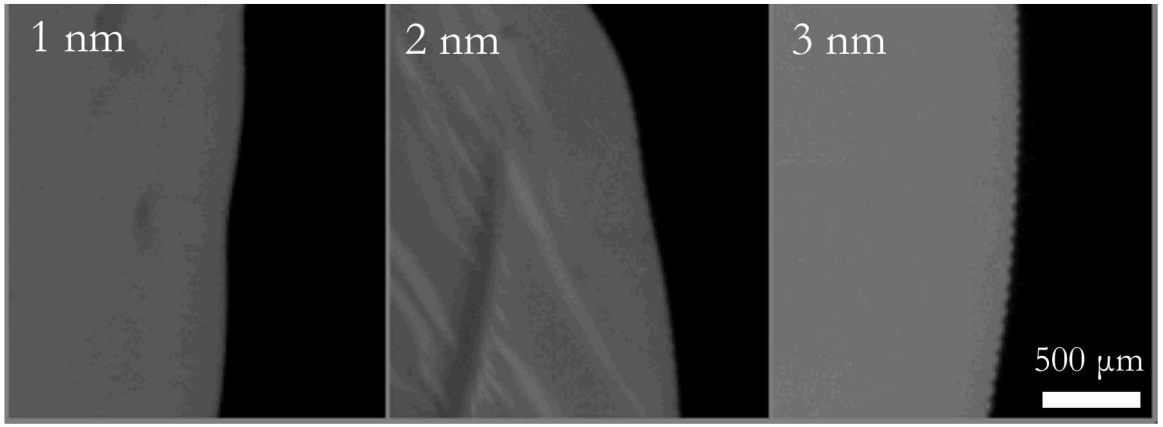
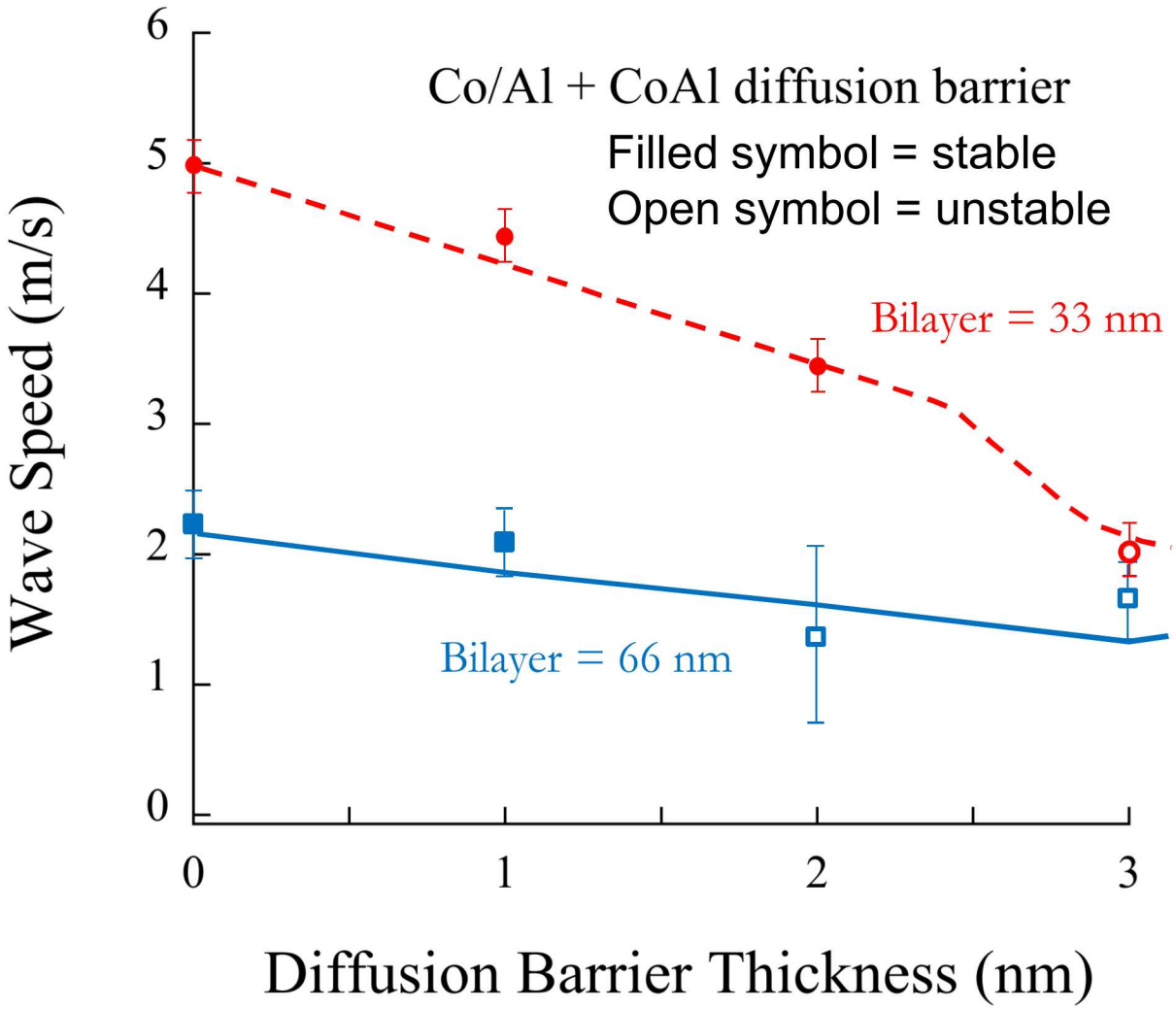
(a) 33 nm Bilayer



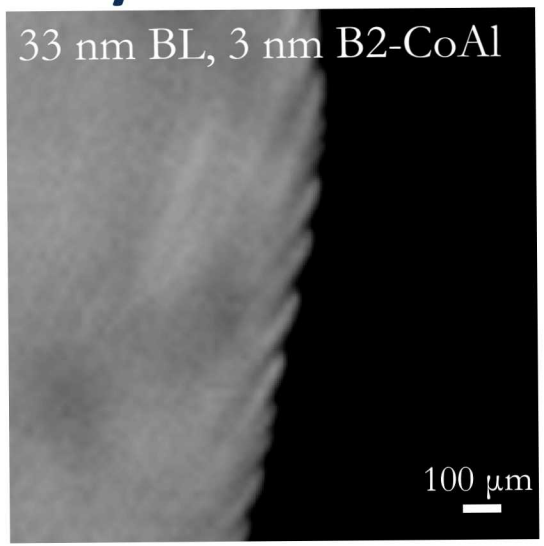
(b) 66 nm Bilayer

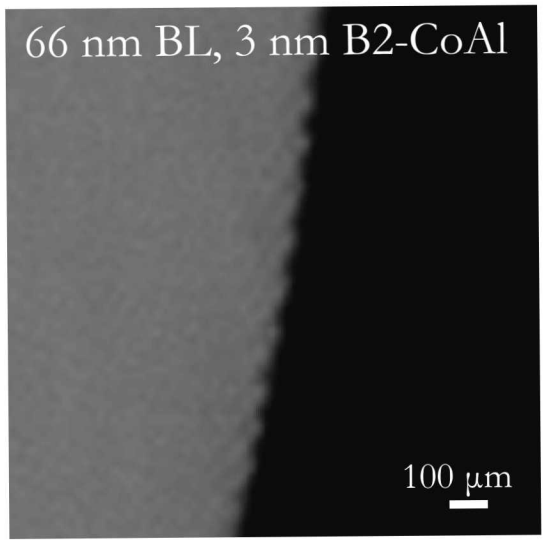


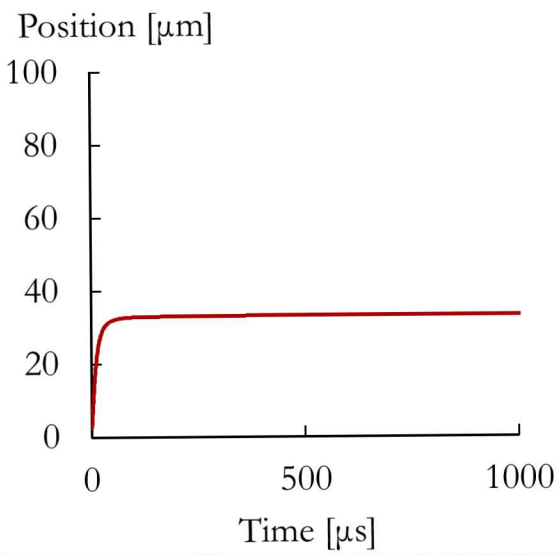
Radial velocity of Co/Al nanolaminates inhibited by diffusion barriers

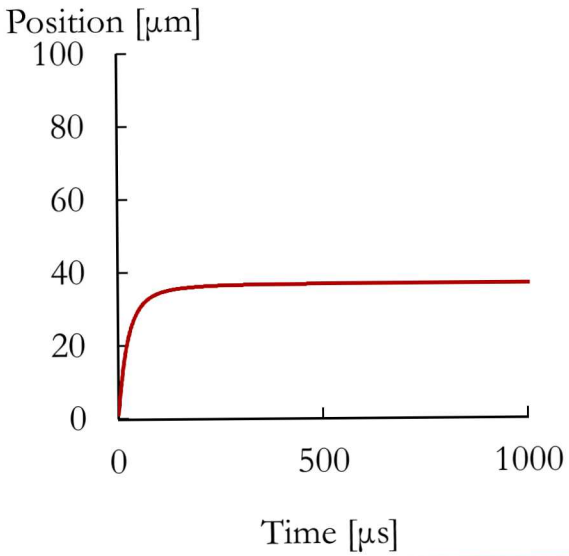


Model fits to spin band widths induced by diffusion barriers









Summary

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We have developed a 1D model that predicts spin band width as a function of forward heat loss into an unreacted foil for a bilayer design at the spin mode threshold

Spin modes can be induced in thinner bilayers by adding a diluent layer or diffusion barrier and their band widths are consistent with the forward heat loss model

This study provides a special case validation for the thermal circuit approach and linear concentration approximation within the Hardt and Phung model for future 3D finite element models of spin bands