Low Temperature Annealing Effects on Magnetron Sputtered Al/Ni(V) Reactive Coatings

CDT Nicholas A. Soroka (USMA)
Matthew P. Blickley (Penn State)

Working with
Dr. John Derek Demaree, Dr. James Hirvonen and Dr. Peter Dehmer

U.S. Army Research Laboratory
Aberdeen Proving Ground, MD 21005

Agenda

- Overview of the Project
- Magnetron Sputtered Reactive Coatings
- Theory behind Thermal Annealing
- Results

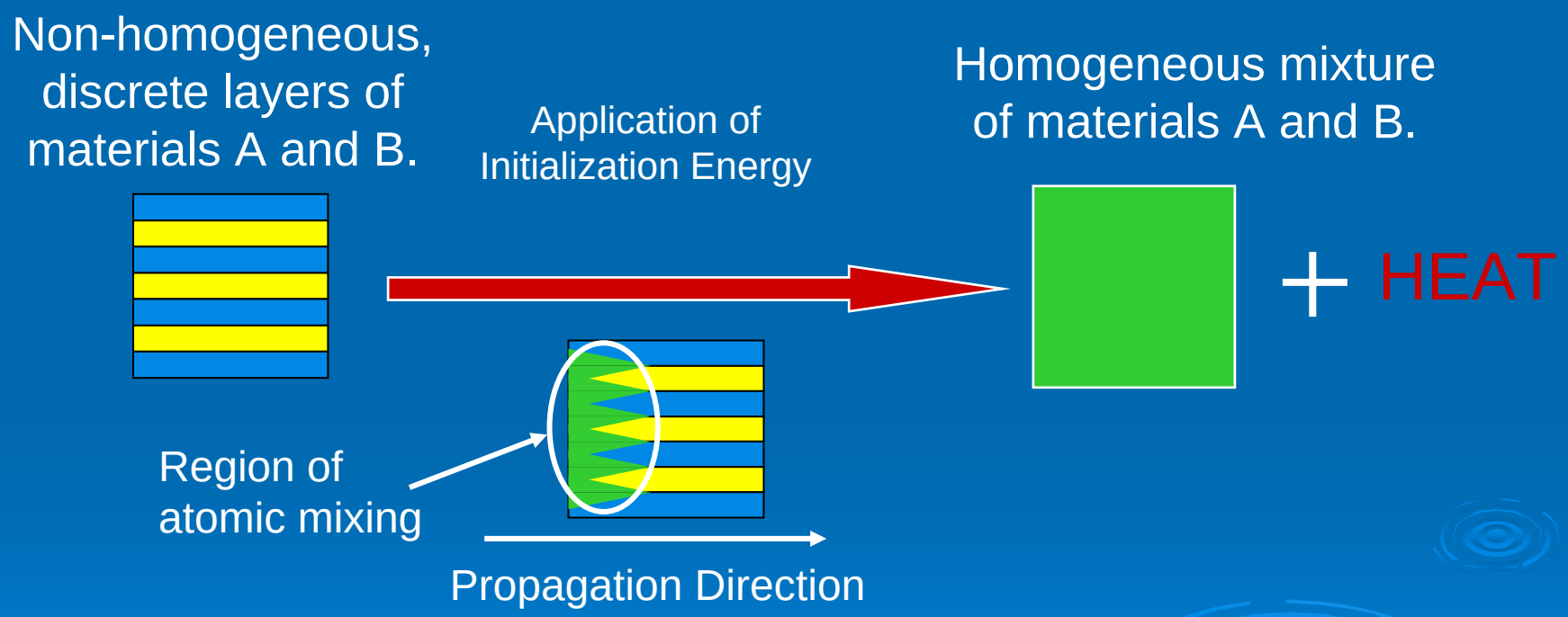
Purpose

Goal: To provide the Army with a non-lethal, indirect fire shell designed to carry a non-lethal payload.

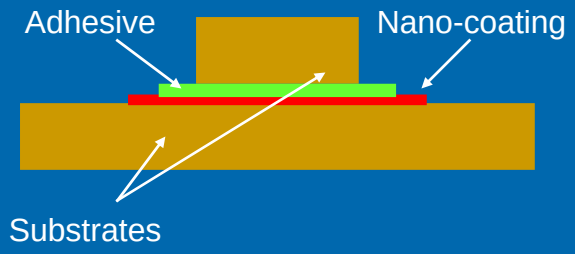
Payoff: Suppress, disperse, engage personnel. Deny access, use, or movement through particular area. Separate combatants from non-combatants.

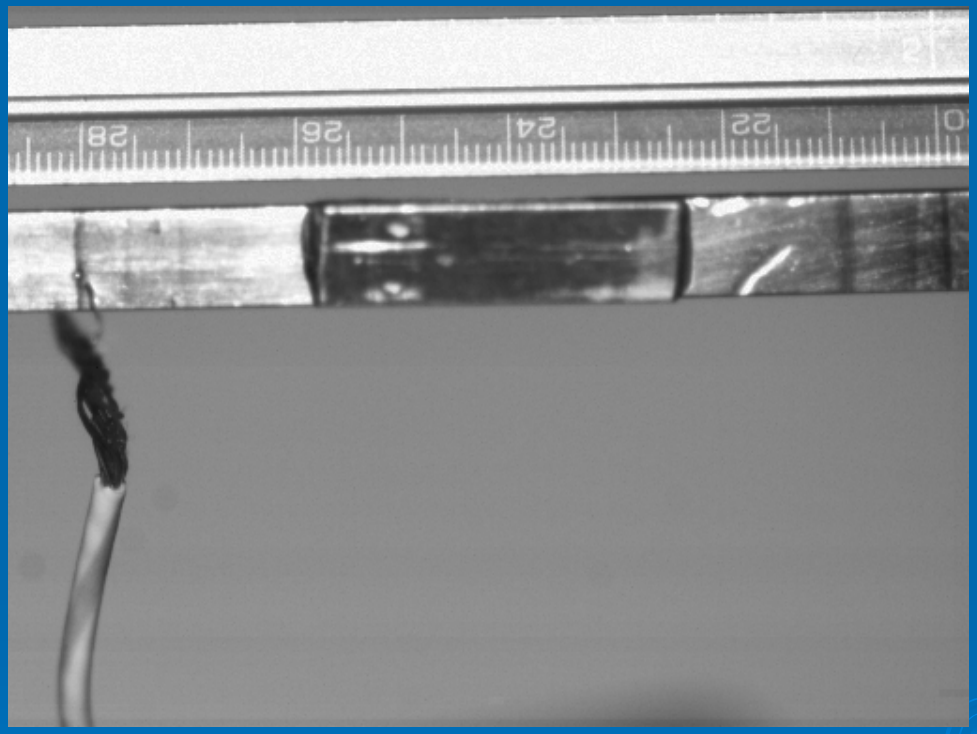
What does this mean?

Reactive Coatings



Reactive Coatings





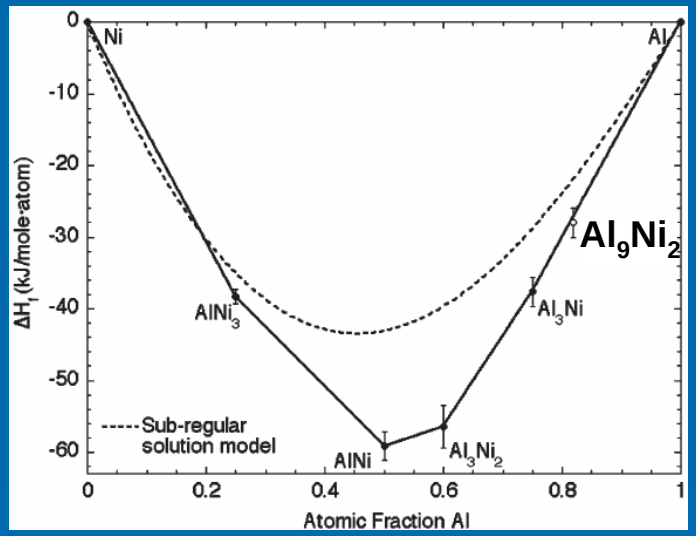
Can we manipulate the sensitivity of reactive coatings?

Prior Literature on Al Ni Interaction

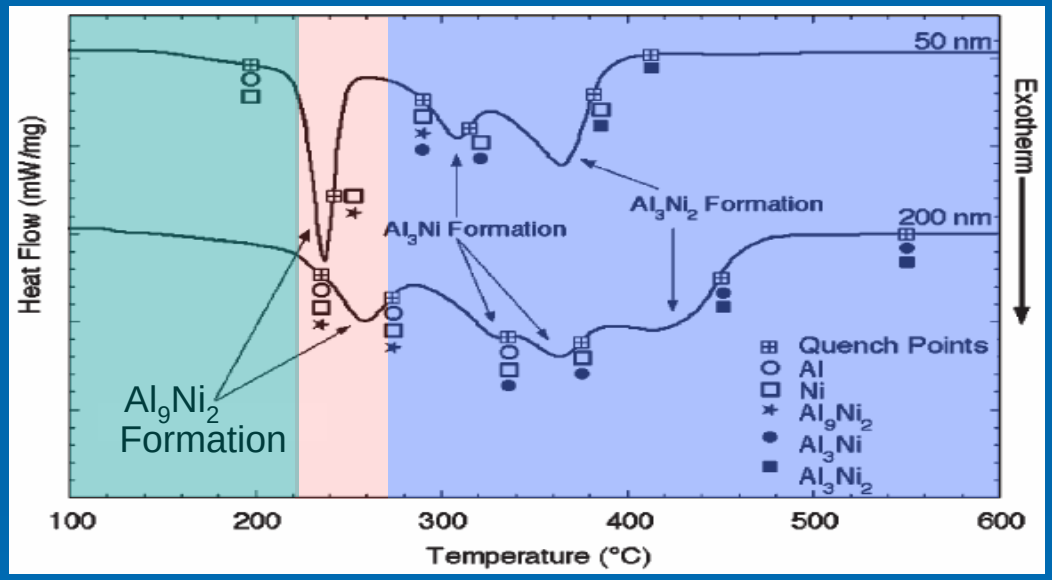
Interdiffusion and Phase Formation effects as reported by Blobaum et al. (2003)

Blobaum K.J., Van Heerden D., Gavens A.J.,Weihs T.P. Al/Ni formation reaction: characterization of the metastable Al_9Ni_2 phase and analysis of its formation. Acta Materialia 2003; 3871-3884.

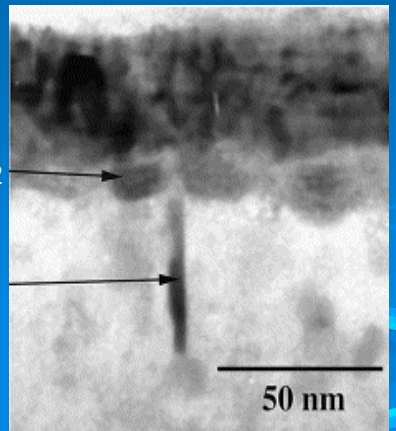
Ni/Al Free Energy Diagram



Differential Scanning Calorimetry (DSC)



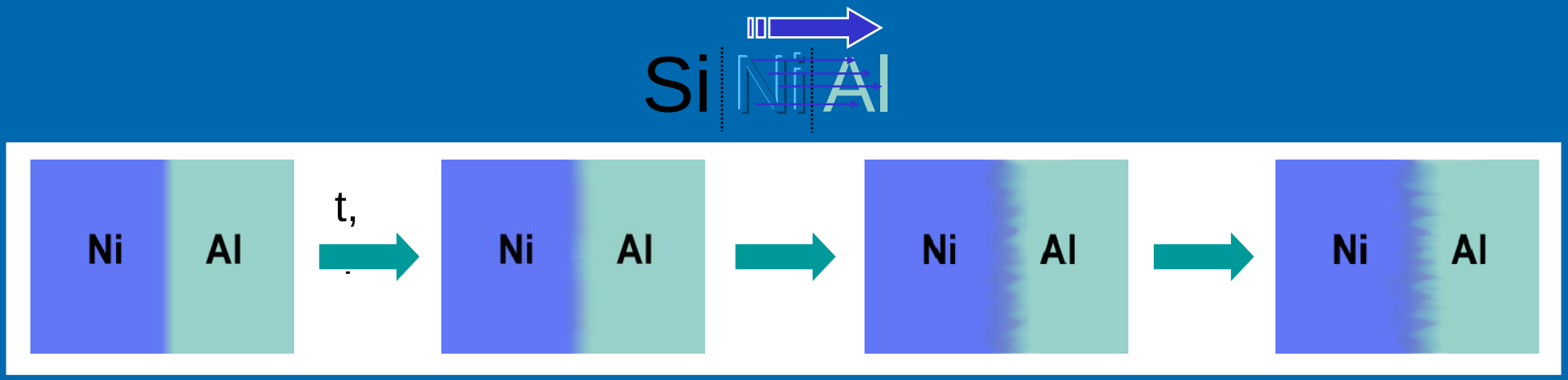
Nickel is the diffuser along Al grain boundaries



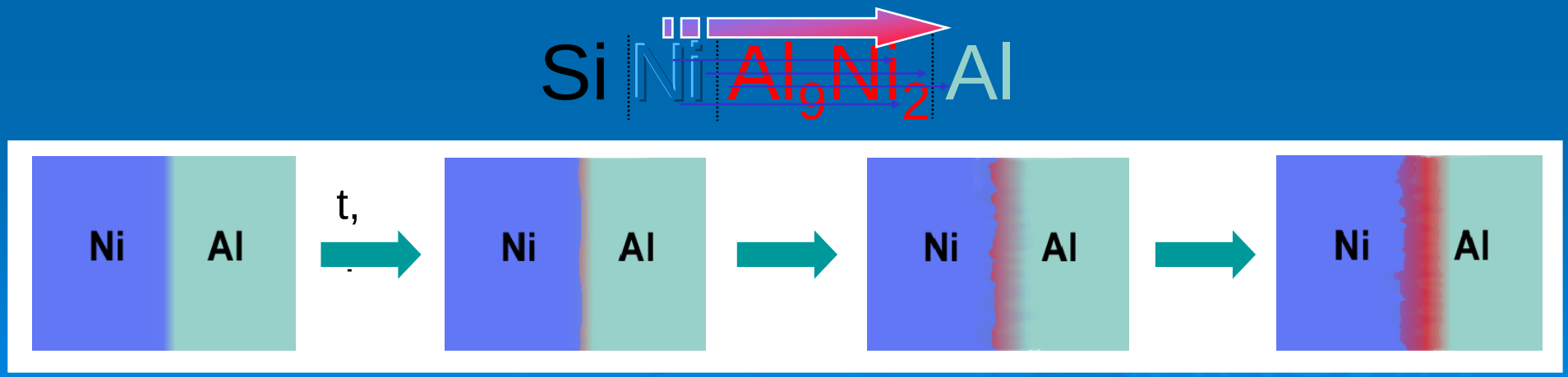
Interfacial Diffusion occurs below the first exotherm

Phase formation occurs above the first exotherm

Low Temp Thermal Anneal of Bilayers



Interdiffusion due to thermal annealing observed below first exothermic shoulder (circa 150°C)



Interdiffusion and Phase formation due to thermal annealing observed above first exothermic peak (230-260°C)

Interdiffusion

- Rutherford Backscattering Spectrometry (RBS)

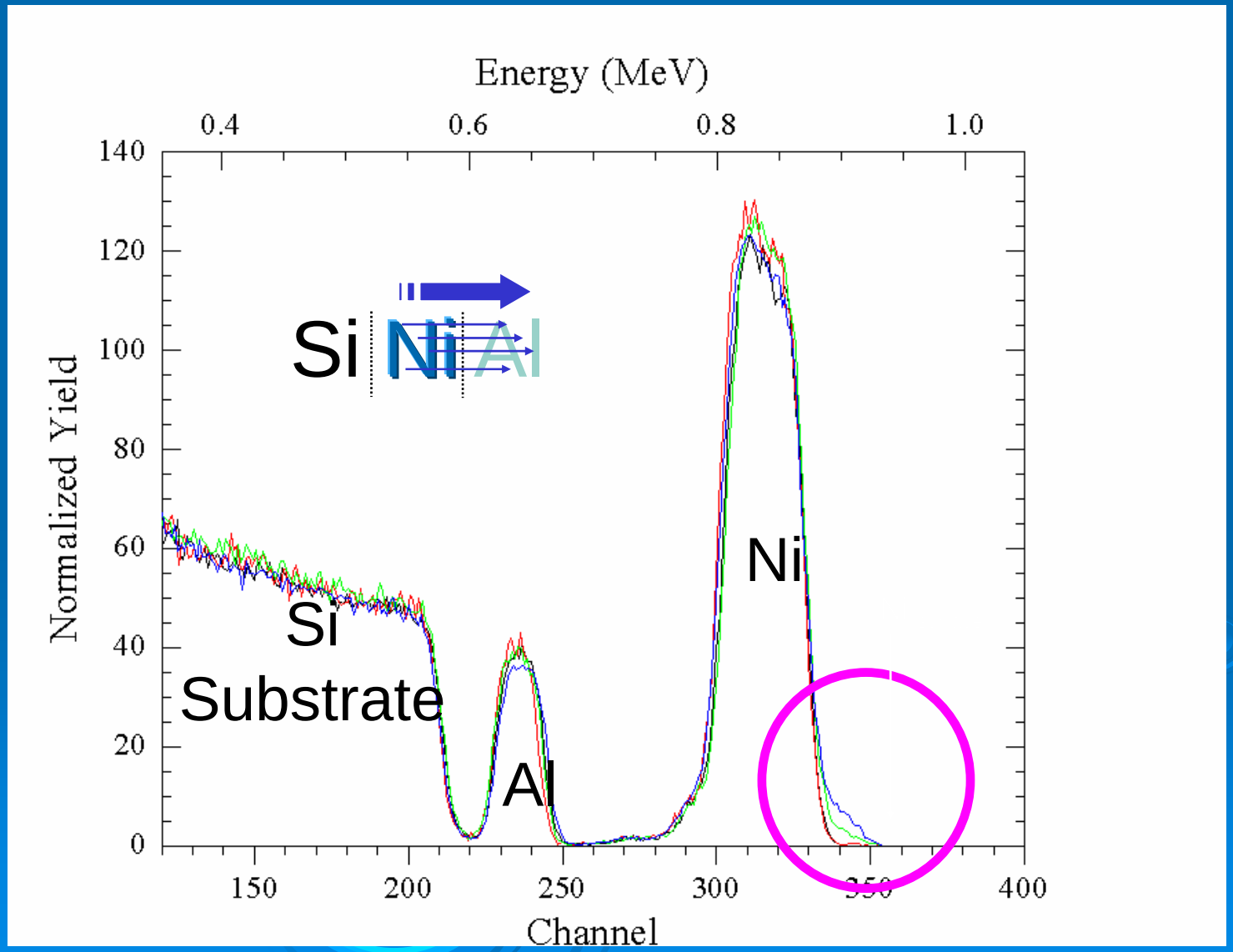
150°C Anneals in Air

No Anneal

1 hour

18 hours

66 hours



Formation of Al_9Ni_2

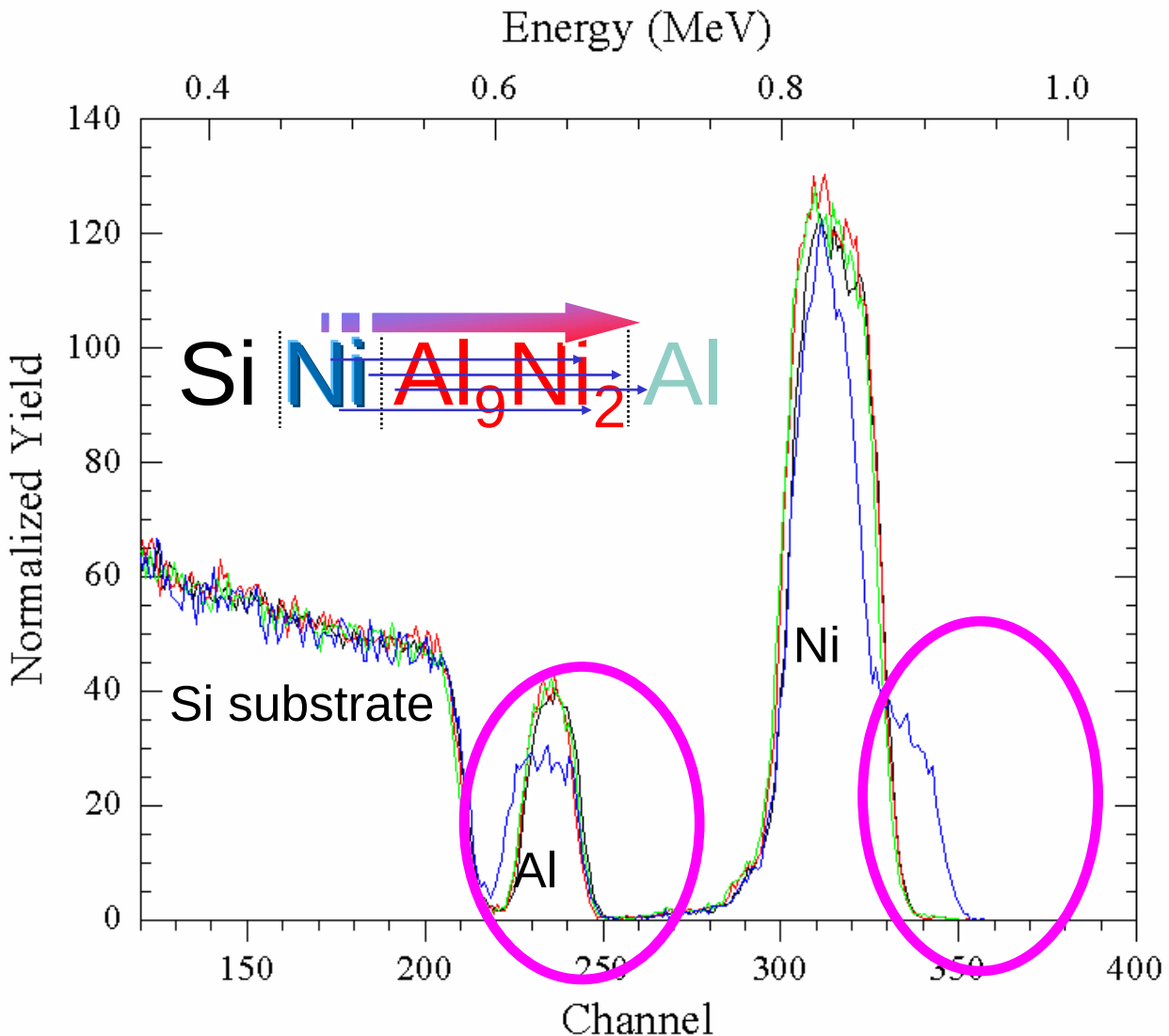
1 Hour Anneal in Air

No Anneal

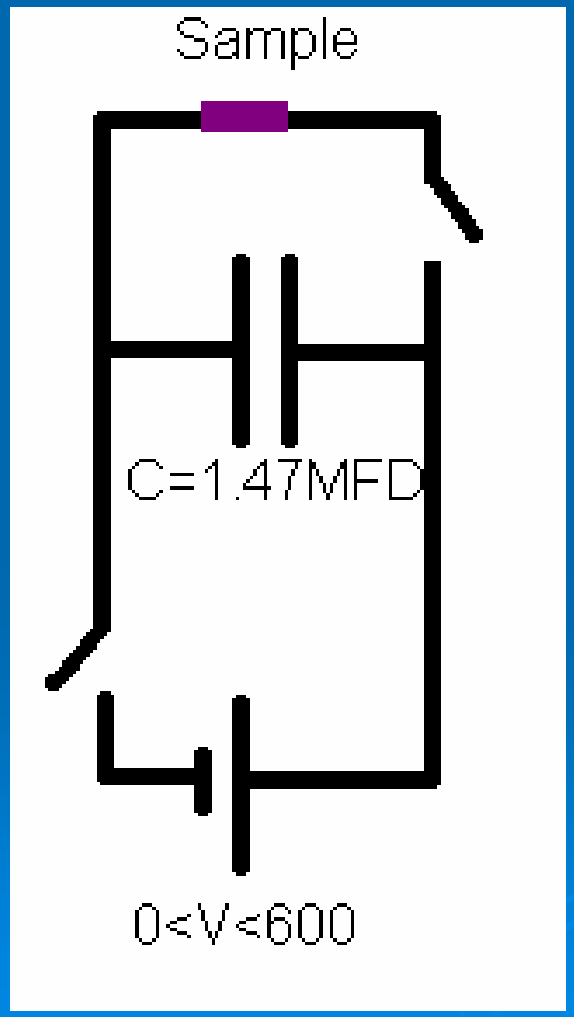
150°C

200°C

250°C

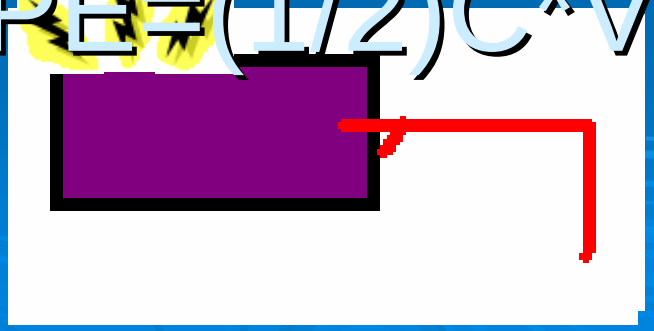


Initiation Threshold Testing



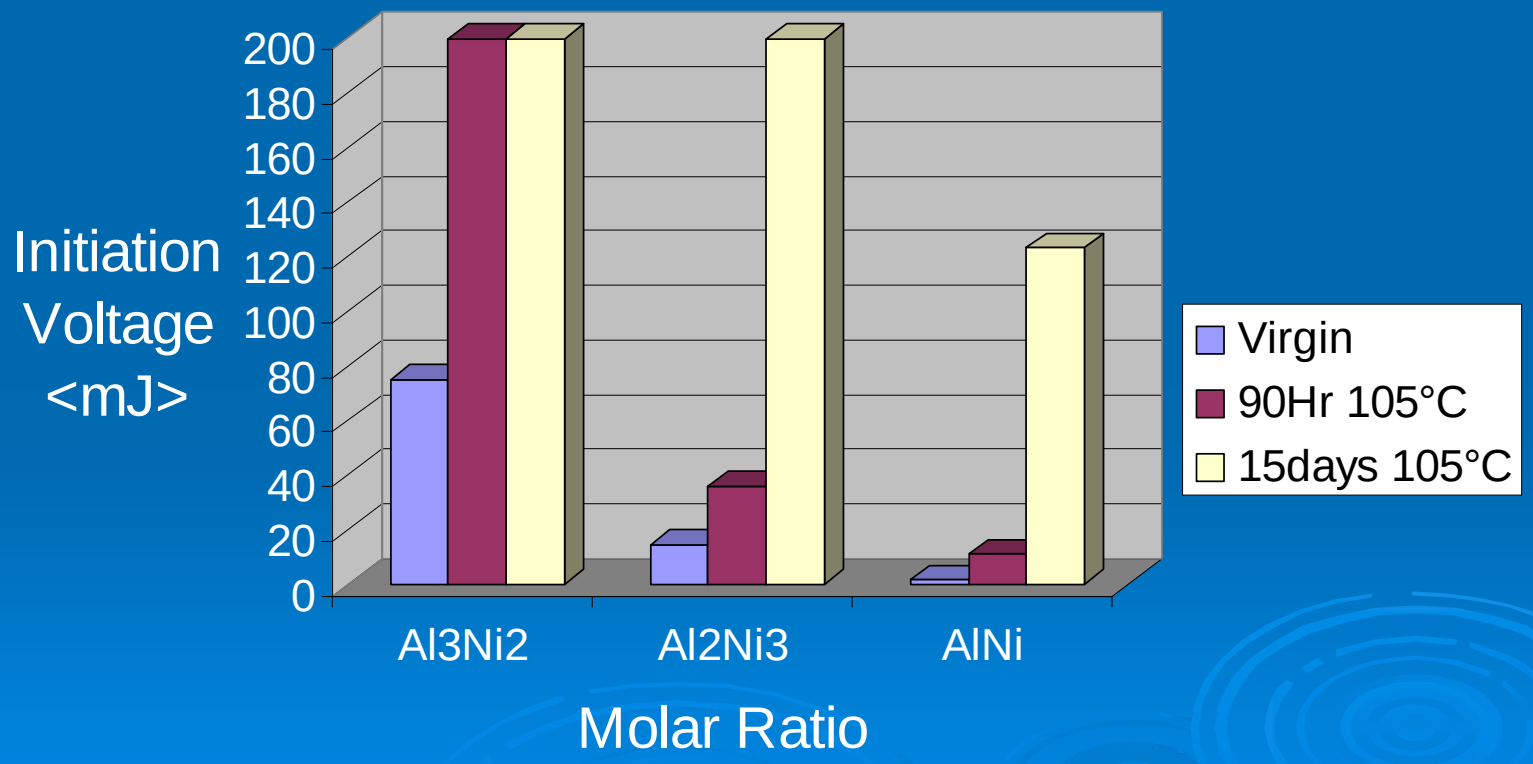
Point contact used to discharge capacitors into sample

$PE=(1/2)C*V^2$



Annealing

Initiation Voltage Threshold



Conclusions

- Can we significantly alter the initiation sensitivity?
- Do we understand the mechanism?
- Intercollegiate cooperation throughout the learning process

Future Work

- Determine shelf life of these foils in fielded conditions
- Determine the effect of annealing on reaction propagation rate
- Optimize adhesion to a specific substrate - composite or metal
- Determine optimal processing conditions for coating large-area staves