Optimization of LR115 Type-II Film-Etching Procedures

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• Founded in 1980 directly as a result of the Elliot lake uranium mine experience
• Operations began in Elliot lake, Ontario in January 1981
• Independent
• Not-for-profit
• Mission:
  – Prevention of cancer, occupational illness and injury from unacceptable exposure to radiation.
PAD Operation

- Uranium-238
- Radon Gas
  - Radon-222
  - Polonium-218
  - Lead-214
  - Bismuth-214
- Polonium-214
- Lead-210
- LR-115 Film
- Collimator
- Mylar
- RaC'
- RaA
- ThC'
- Filter
- Pump
The number of tracks in each region of the film is correlated to the exposure
Problem

• Film supplied by Dosirad in France
  – Created by Jean Andru, after Kodak DSTN closed in 1992
  – Jean Andru passed away (unexpectedly)
  – Knowledge regarding manufacture of LR-115 has been lost

• Variation in thickness of older film

• Need to determine how to adjust etching conditions to compensate
Basics of SSNTD’s

• Nominal emulsion thickness of 12 µm
• Range of alpha’s makes film sensitive to 2.7 MeV alpha particles.
• Parameters affecting vb/vt
  – Molarity of NaOH
  – Temperature of NaOH
  – Etching Time
  – PH of rinsing solution
Factorial Designed Experiments

- Varying one at a time is not practical, and won’t measure interaction between variables.
- Two variables = 4 runs.
- In general $2^n$ runs required.

Max = 65 degrees for 95 mins
Max = 95 mins at 70 degrees
Factorial Design

- Initial Screening Experiment
- Response Variables
  - Mean signal tracks
  - Mean background tracks
  - Track Diameter
- 8 films per run
- Signal tracks exposed with air gapped Am-241 source for ~16 mins.

- $2^2$ design
- Temperature of 65°C
Signal Regression Coefficients

\[ \text{Signal} = 169.34 - 5 \cdot \text{Molarity} - 2.3 \cdot \text{Time} - 4.1 \cdot \text{Molarity} \times \text{Time} \]

\[ \text{Diameter} = 4.77 - 0.3 \cdot \text{Molarity} + 0.3 \cdot \text{Time} + 0.64 \cdot \text{Molarity} \times \text{Time} \]
Background Results

• Background Regression Coefficients

\[ \text{Signal} = 3.6 - 0.16 \cdot Molarity + 0.9 \cdot Time + 0.41 \cdot Molarity \times Time \]
\[ \text{Diameter} = 3.66 - 0.02 \cdot Molarity + 0.24 \cdot Time + 0.04 \cdot Molarity \times Time \]
Selecting Operating Conditions

- 60 mins, at 2.5 M, at 65 C provides the optimum etching conditions
- Licensed Dosimetry Service
  - Needed to collect additional commissioning data before implementing any changes
Conclusion

• Summary
  – Variation in thickness of LR-115 meant changes to etching parameters was necessary
  – Conducted $2^2$ factorial experiment to select time, molarity
  – Interaction between changes in molarity and etching time
  – 60 mins, at 2.5 M, at 65 C provides the optimum etching conditions
Questions?