Effect of Calcium on TBR of ARIES-RS Li/V Blanket

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Background

- Li/V blanket requires electric insulator coating on V alloys structure to minimize MHD pressure drop during Li flow in magnetic field
- ANL has recently examined several coatings over wide range of temperatures and Li chemistries*:
  - Oxide coatings: CaO, MgO, BeO, Y_2O_3, $MgAl_2O_4$ (spinel)
  - Nitride coatings: BN, AlN, Si_3N_4
- Goal: $\Delta.\rho > 100\ \Omega.cm^2$ @ 500-700 °C
  $\rho = 10^6\ \Omega.cm$ for 1 μm coating
- BN offers highest resistivity (ρ) followed by CaO
- Based on thermodynamic stability in Li system, CaO was selected as candidate coating for Li/V blankets

* K. Natesan et.al., "Electric Insulting Coatings for V-Li Self-Cooled Blanket in a Fusion System," ANL/TD/TM00-10 (May 2000)

Experimental Results

Formation method of CaO coating	Main Features
CVD	– 100% CaO coverage on V – Adherent coating – Thick layer (20-30 μm) – $\rho > 10^6$ Ω.cm $\Delta.\rho >> 100$ Ω.cm^2
In-situ in Li-Ca environment (self-healing process)	– Thickness (Δ) is much less than desired – Non-uniform composition on V – Many bare V areas – Acceptable ρ @ 350 °C, but drops substantially at higher temperatures

Main conclusion: CaO is viable coating for Li/V blanket but needs significant additional effort to enhance coating structure and electric resistivity

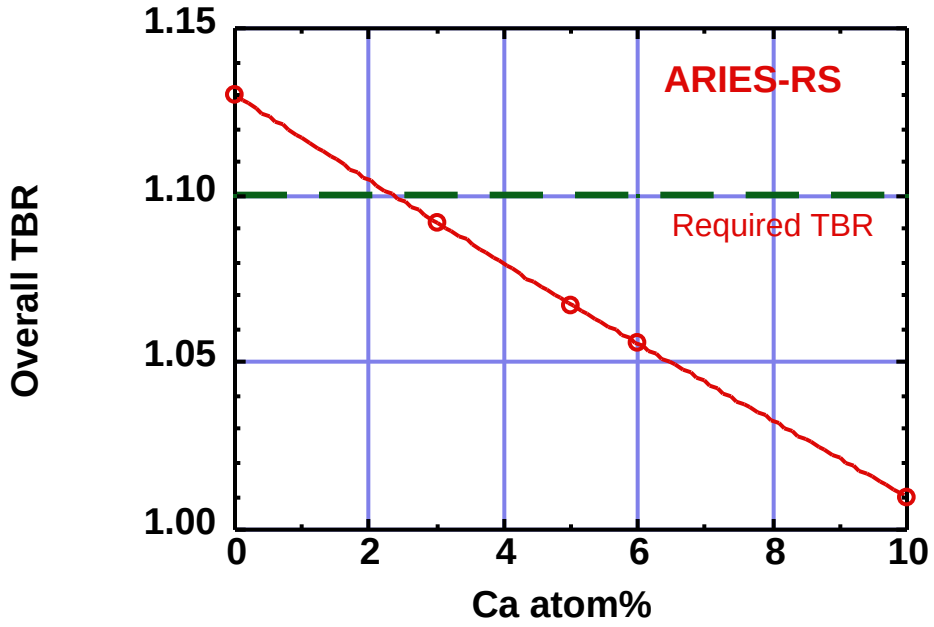
ARIES-RS Li/V Blanket

- Main parameters:
  - 20 cm and 50 cm thick IB and OB blankets, respectively
  - 10% V4Cr4Ti and 90% Li, by volume
  - Natural Li
  - Overall TBR = 1.13

- Per Wiffen, 1-10 atom% Ca in Li might be needed, but requirement is not yet known

- Assess impact of Ca on TBR of ARIES-RS

Calcium Degrades TBR by 1-10%, Depending on Ca Content



- Ca has higher cross-section than Li for fast n's (E_n > 0.1 MeV)
- Reference ARIES-RS blanket can tolerate 2 atom% Ca without changing design

Higher Ca Content Requires Design Change(s) to Compensate TBR Losses

- Potential solutions to meet breeding requirements include:
  - Limit Ca content to ≤ 5 atom%
  - Thicken OB (and IB) blankets
  - Enrich Li to 10-20%
  - Add Be (or Be_2C) to blanket/reflector
- Economic penalty and safety impact of changes need to be assessed
- Results have been sent to Wiffen, Muroga, Suzuki (NIFS), Smith (ANL), and Zinkle (ORNL)