

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, Y₂O₃, MgAl₂O₄ (spinel)
 - **Nitride coatings:** BN, AlN, Si₃N₄
- Goal: **$\Delta\rho > 100 \Omega\cdot\text{cm}^2$** @ 500-700 °C
 $\Rightarrow \rho = 10^6 \Omega\cdot\text{cm}$ 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 Insulating 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)
- $\rho > 10^6 \Omega\cdot\text{cm}$
 $\Rightarrow \Delta\rho \gg 100 \Omega\cdot\text{cm}^2$

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 $^\circ\text{C}$, 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

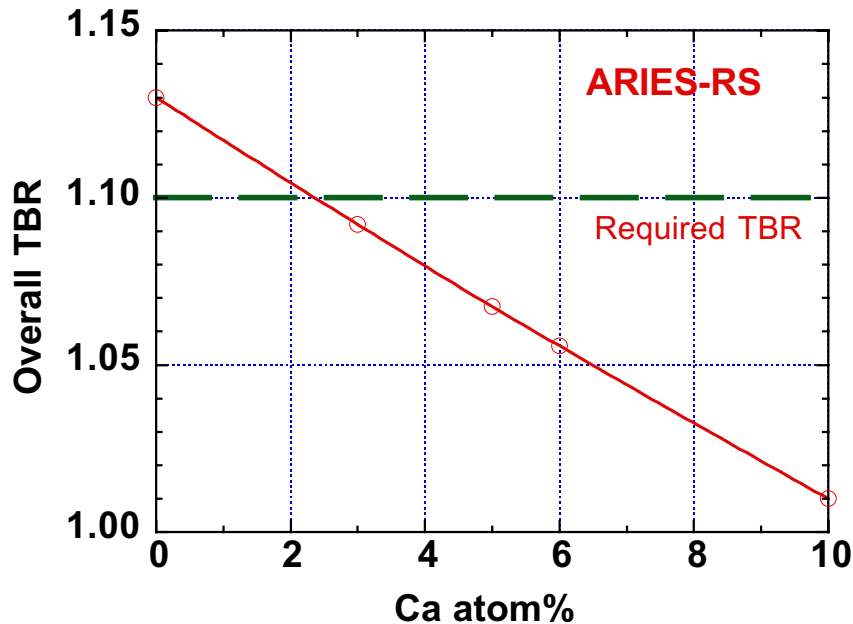


ARIES-RS Li/V Blanket

- **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)

