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Assessment of ternary pyrotechnic compositions thermal conductivities using binary and multi-scale model

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• Introduction

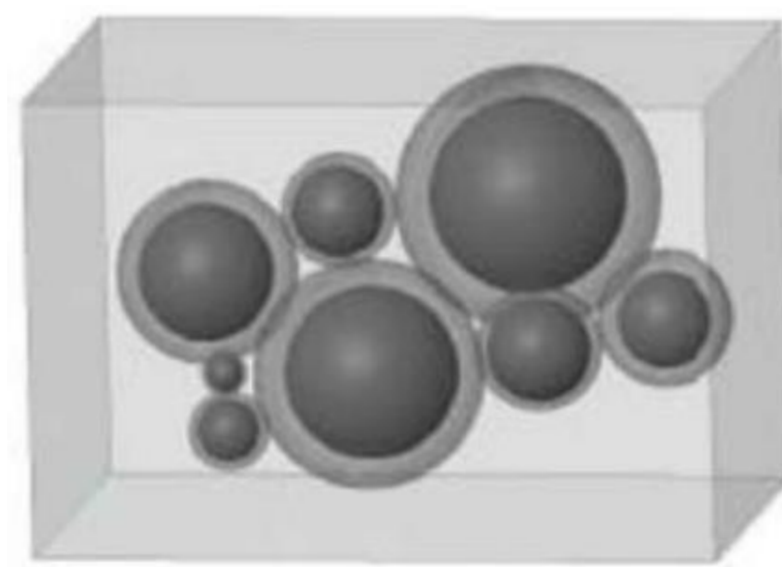
- ✓ Thermal conductivity: key parameter to simulate combustion of pyrotechnic compositions, difficult to obtain.
- ✓ Existing models only for two components. To apply to pyrotechnic compositions: a multi-layer bi-component approach is proposed.
- ✓ A ternary composition is studied: SrO₂ as oxidiser, Mg as reducer and DNAN as an energetic binder. A first layer of two components (SrO₂/DNAN) is studied, then the second one is made of one (or more) grain of Mg encapsulated by the previous layer. The third layer is the previous pyrotechnic grain and the air.

• Studied model

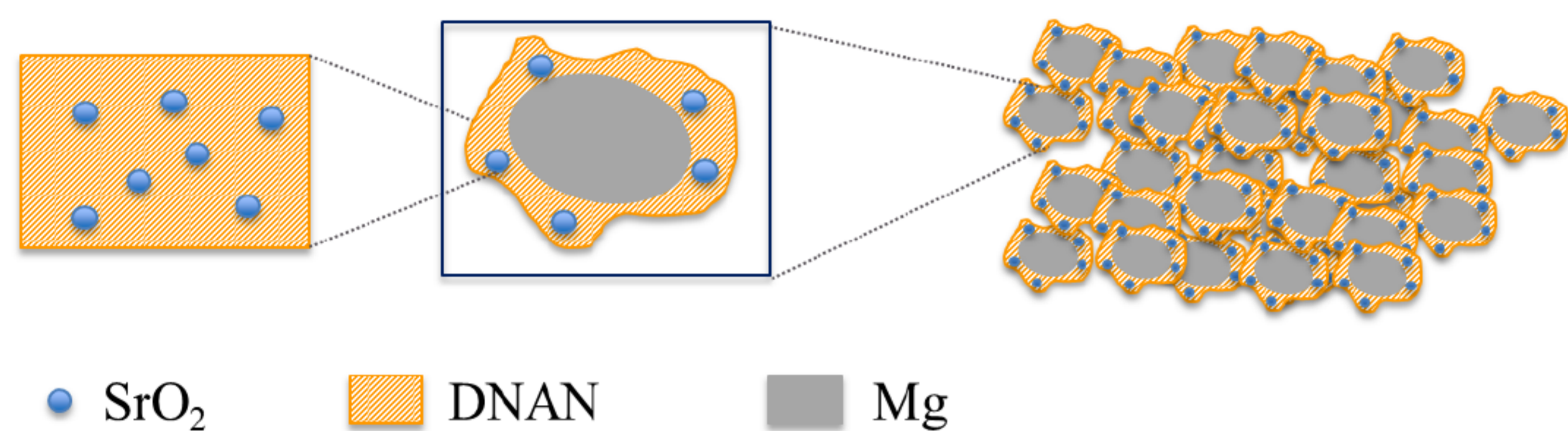
✓ Hashin & Shtrikman

$$\lambda_{eq}^- = \lambda_2 + \frac{f_1}{\frac{1}{\lambda_1 - \lambda_2} + \frac{f_2}{3\lambda_2}}; \lambda_{eq}^+ = \lambda_1 + \frac{f_2}{\frac{1}{\lambda_2 - \lambda_1} + \frac{f_1}{3\lambda_1}}$$

f_1 volumic fraction of inclusions; f_2 volumic fraction of matrix (shell) = $\left(\frac{a}{b}\right)^3$
 a : nucleus radius – b : external shell radius

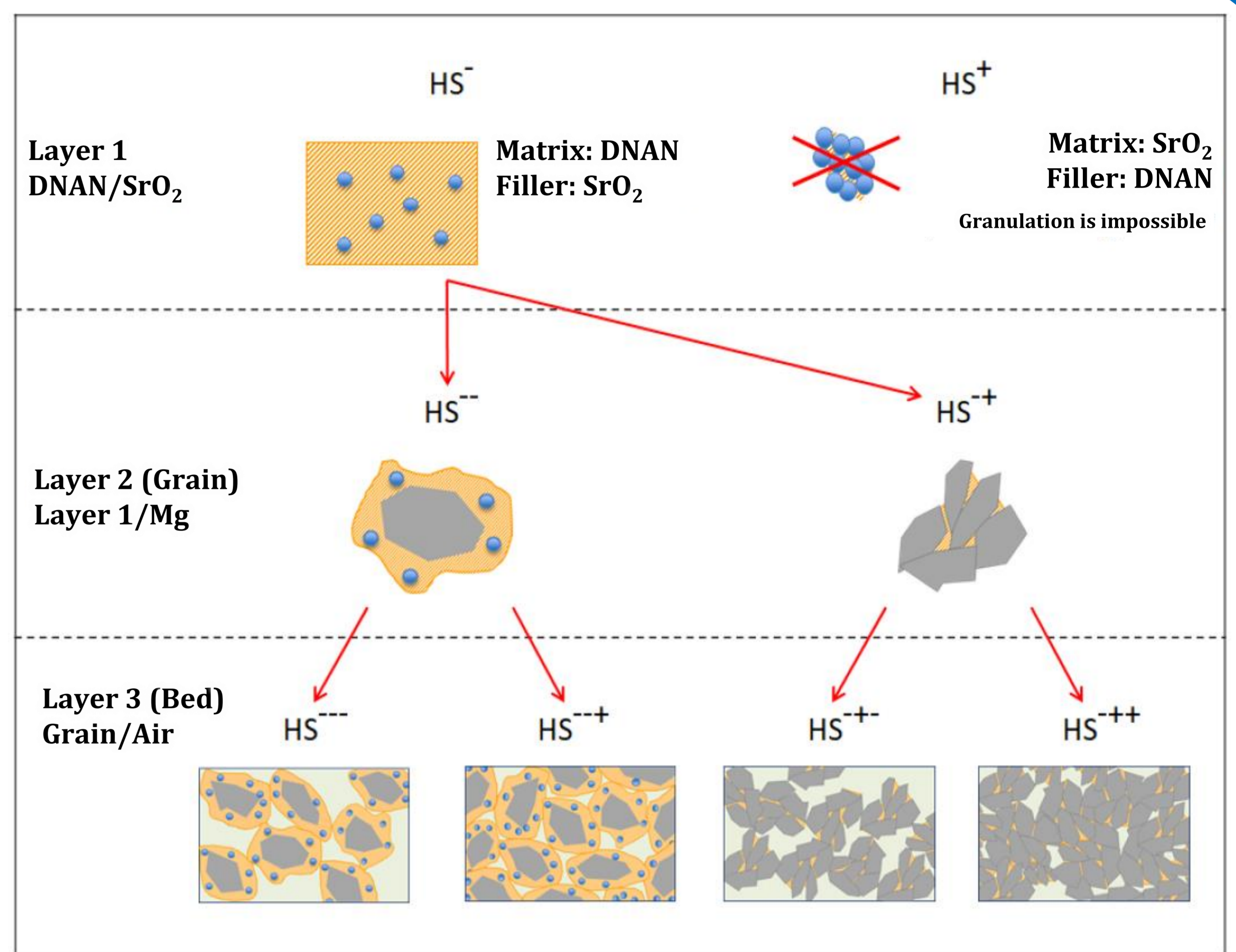


• Multi-layer hypothesis

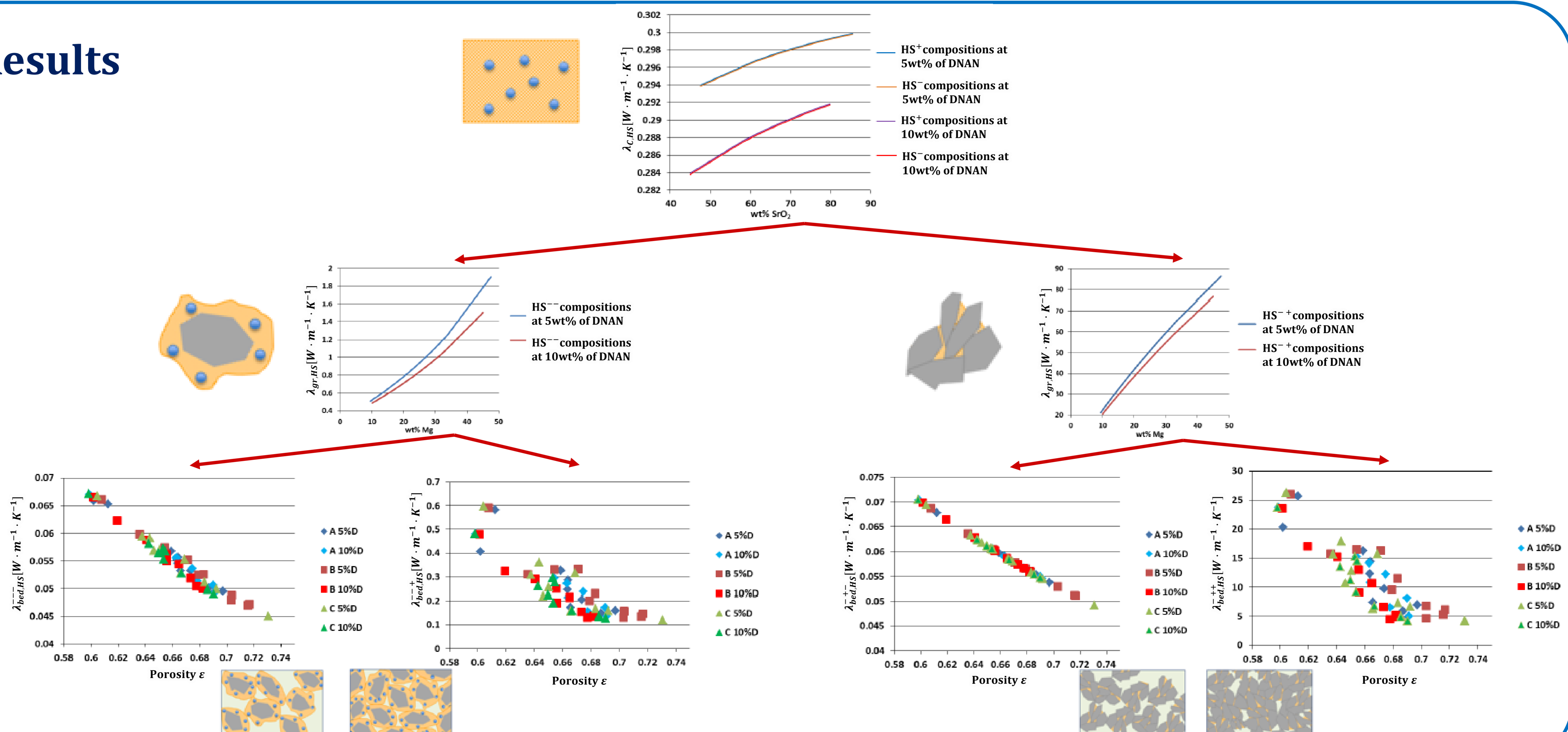


• SrO₂ • DNAN • Mg

Air in pores implemented as a 4th component: $\varepsilon = 1 - \frac{\rho_{app}}{\rho_{th}}$



• Results



• Conclusion

Multi-scale approach to obtain thermal conductivity of pyrotechnic compositions has been performed. The influence of components ratio has been shown. SEM pictures could be used to assess which path (HS⁻ or HS⁺) should be chosen. HOTDISK measurements could also help to determine the validity of these calculations.