



# Networking and Brokerage Event Horizon Europe MSCA Staff Exchanges Call 2026

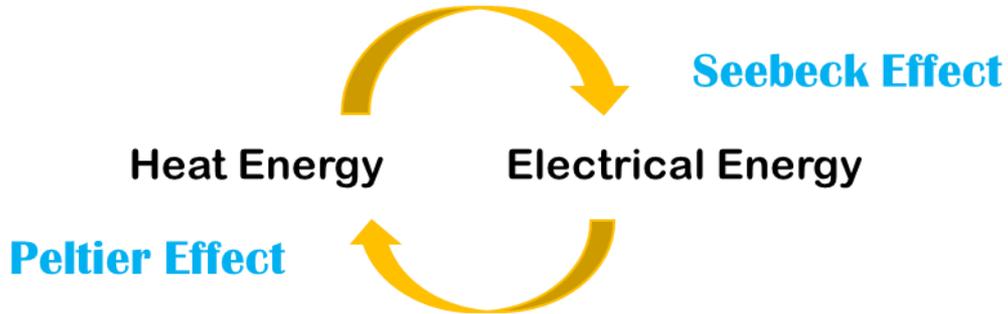
## Crystalline defects engineering for optimizing functional properties

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- Defects Engineering to optimize the electron and phonon transport properties of immiscible semiconductors
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# Thermoelectric Device

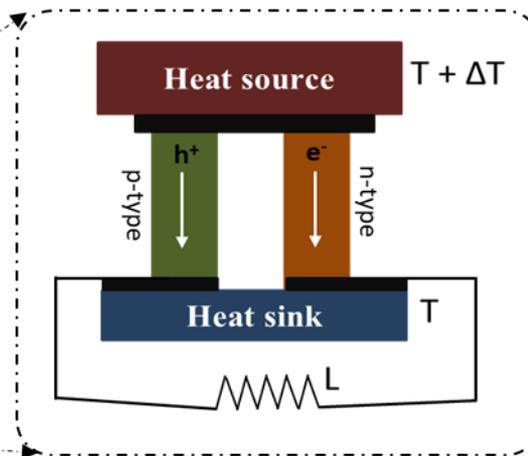
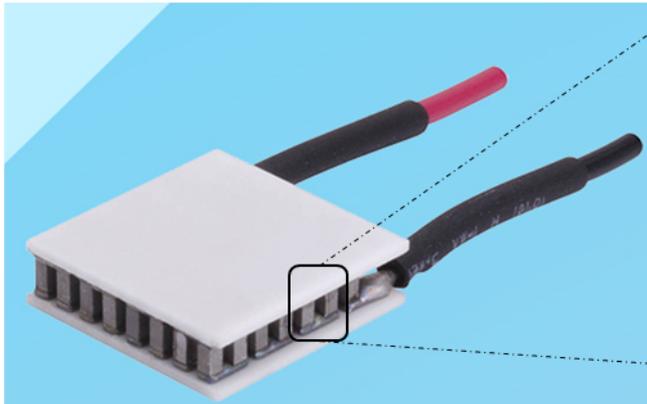
## Thermoelectric devices - Principle



## Advantages

- No moving parts
- Stable for long term use
- Eco-friendly
- Solution to reduce global warming

## Thermoelectric module



# Phonon contribution to thermal conductivity

$$ZT = \frac{\sigma S^2}{\kappa} T$$

$$\kappa = \kappa_e + \kappa_l$$

$\kappa_e$  – Electronic contribution

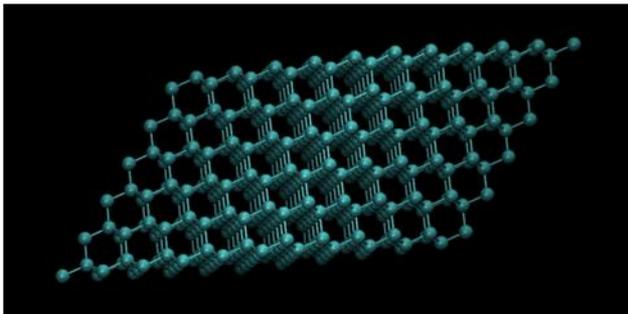
$\kappa_l$  – Lattice contribution

Major issue

**Lattice thermal conductivity ( $\kappa_l$ ) contributes, over 80 % of total  $\kappa$  value  
in most of the semiconductors**

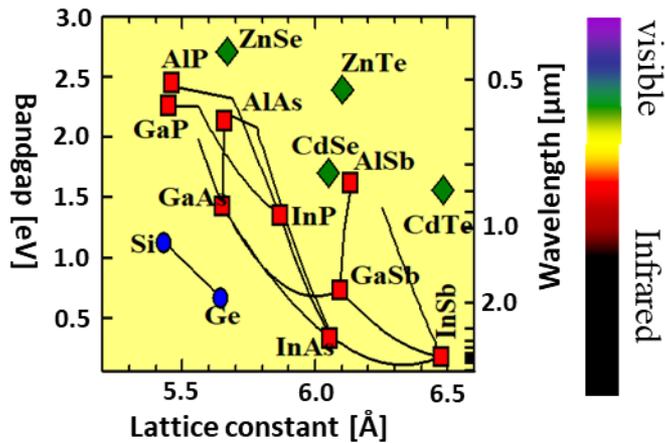
## Phonons

*(Conduct heat by lattice thermal conductivity)*



- Virtual atomic position by thermal agitation
- Carries above 80 % of total thermal conductivity in most of the semiconductors
- Controlling virtual atomic positions could enhance TE performance

# Properties of InGaSb immiscible alloy



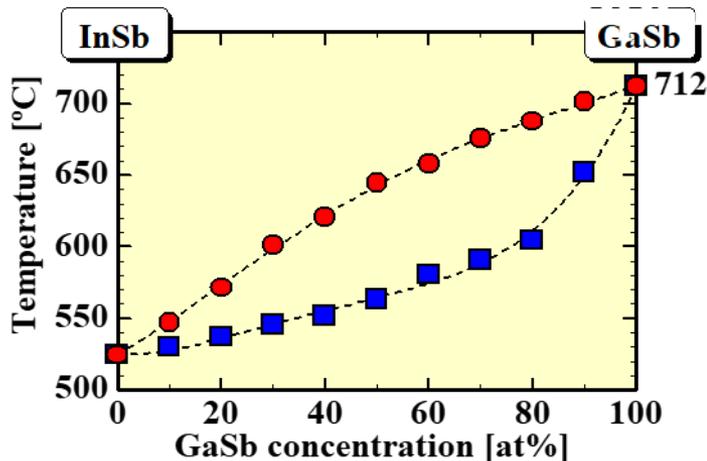
Properties of  $\text{In}_x\text{Ga}_{1-x}\text{Sb}$ :

- Lattice constant : 6.096 ~ 6.479 Å
- Wavelength : 1.7 ~ 6.8 μm (IR region)

- Posses superior electrical properties

$\text{In}_x\text{Ga}_{1-x}\text{Sb}$ : *Thermoelectric application...?*

**Major issue:** High thermal conductivity ( $\kappa$ ) (> 20 W/mK)  
(Efficient TE materials posses  $\kappa < 1$  W/mK)



Phase diagram of InSb-GaSb

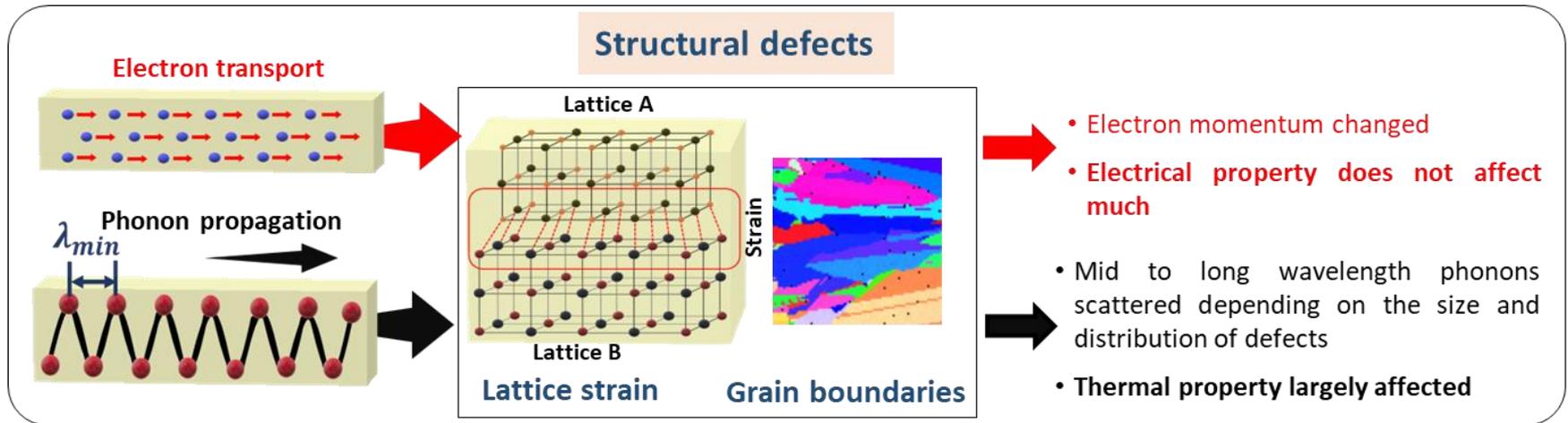
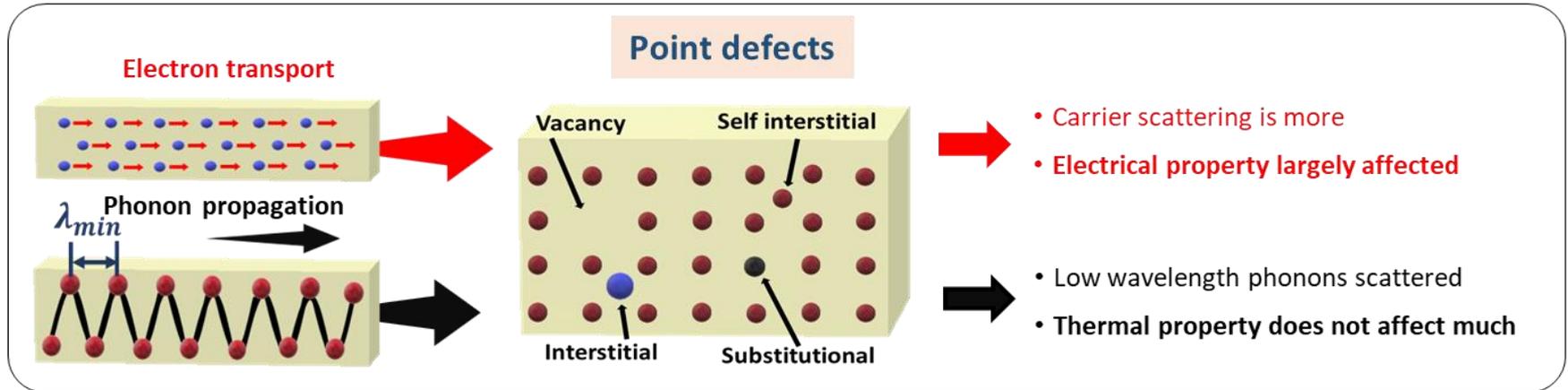
- Large separation between liquidus and solidus
- High segregation coefficient

## Hypothesis

Natural segregations in  $\text{In}_x\text{Ga}_{1-x}\text{Sb}$  could restrict the phonon transport through crystal lattice

# An approach to improve the TE properties

## The effects of 'charged' and 'structural' defects on the thermoelectric properties of a crystal

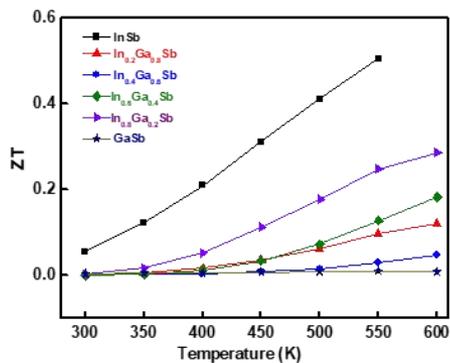
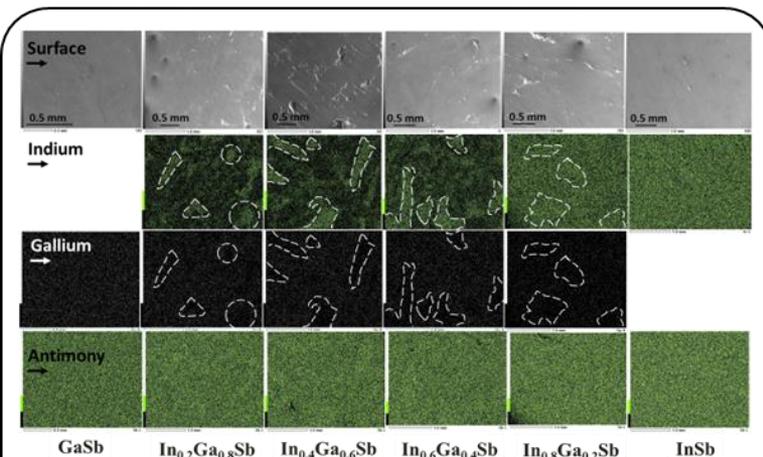


Strategy for better thermoelectric performance:

Reducing 'charged defects' and increasing 'structural defects' in crystalline semiconductor materials

# Our works on defects engineering

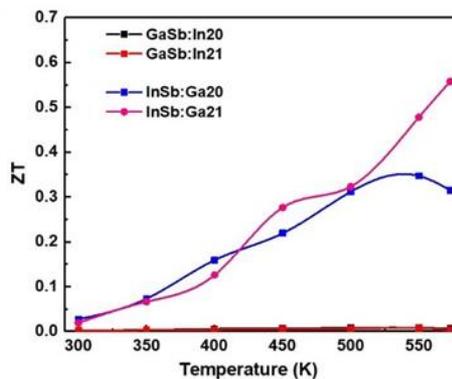
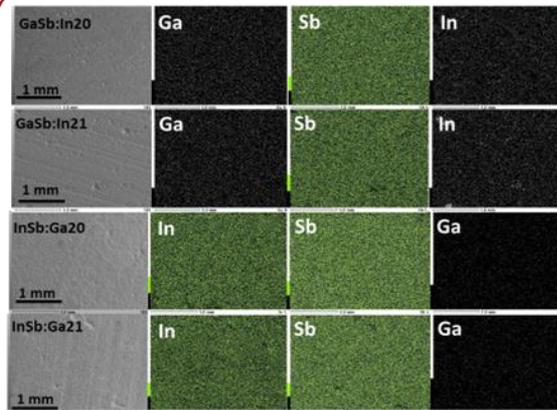
## Segregations (mm) in $\text{In}_x\text{Ga}_{1-x}\text{Sb}$



- Max. ZT of InSb : **0.49**
- Max. ZT of InGaSb : **0.29**

\*Appl. Phys. A 122 (2016) 885

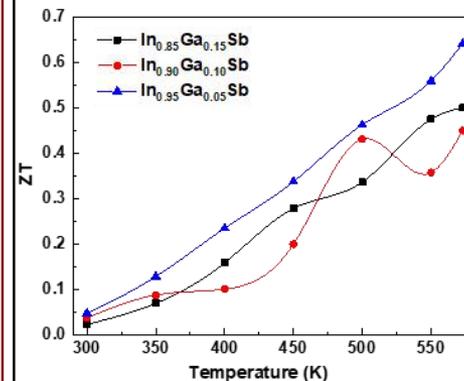
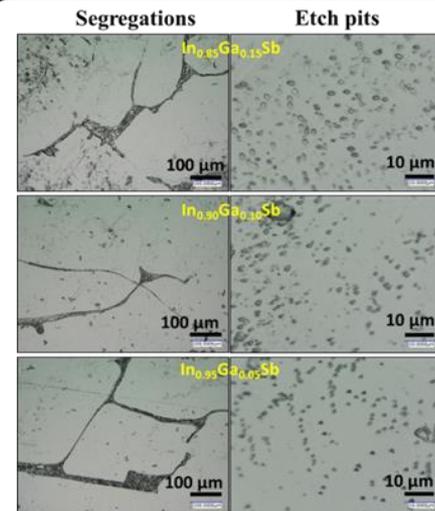
## Compositional homogeneity



- ZT improved about 10 % (**0.54**) in Ga doped InSb

\*Intermetallics 105 (2019) 21–28

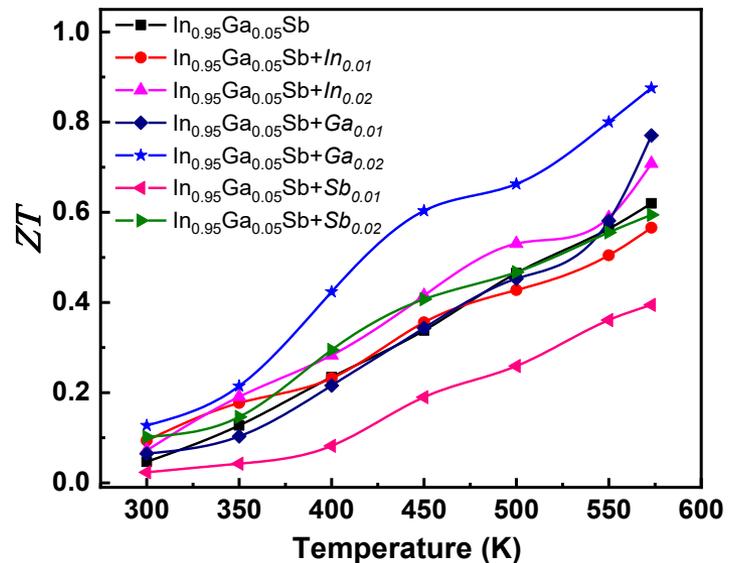
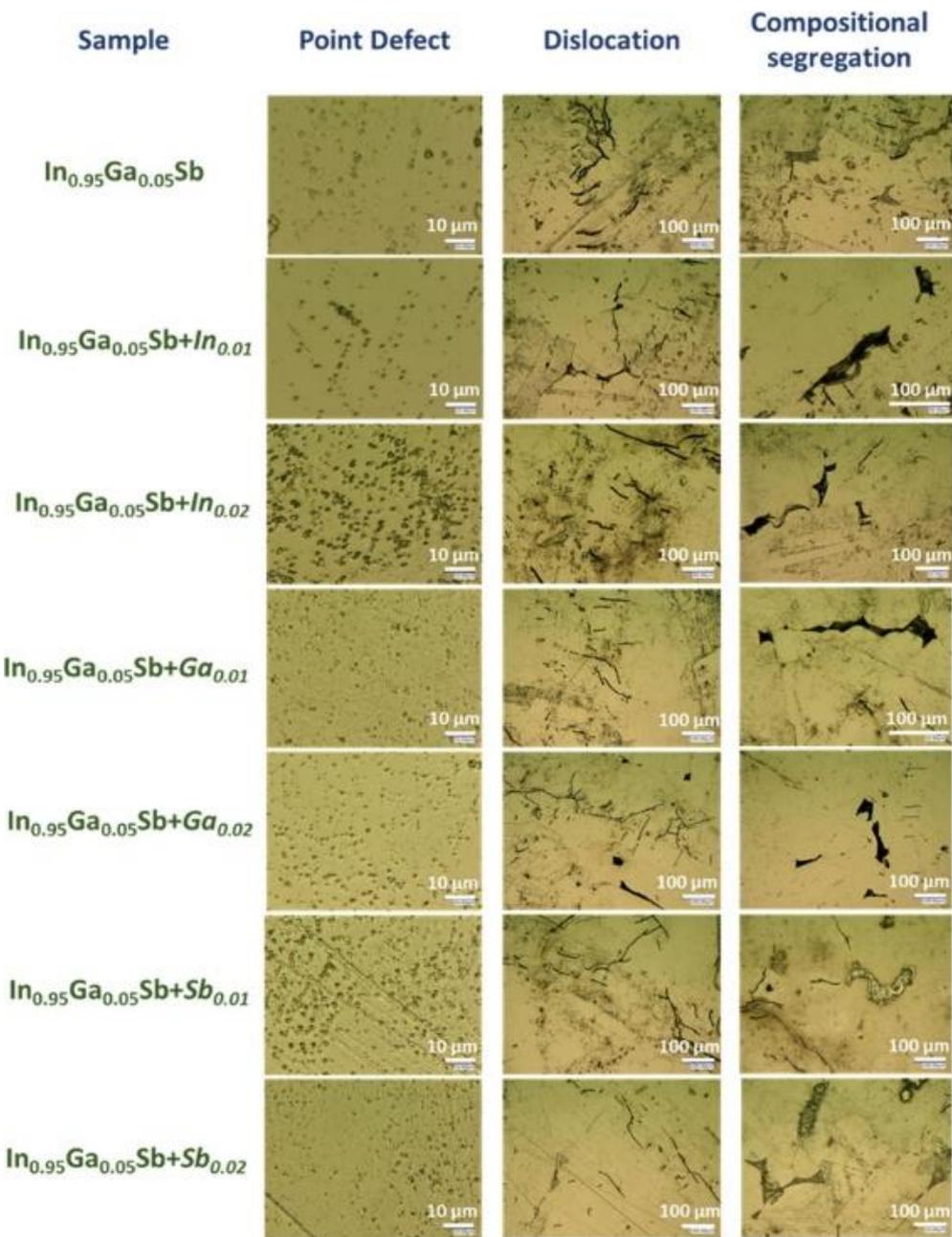
## Micro-scale segregations



- Max. ZT of InGaSb : **0.62**
- ZT improved above 100 %

\*Inorg. Chem. 58 (2019) 11579–11588

# Enhancement in the electron and phonon transport properties by defects engineering



The  $ZT$  of InGaSb is enhanced up to **0.87**, the highest among other III-V semiconductors

The interrelated electron and phonon transport properties in crystalline materials could be enhanced—without much affecting the electron transport properties—by defects engineering via point defects and compositional segregations.

# Expertise we can offer

- High-temperature crystal growth from melt
- Growth kinetics control to achieve compositional homogeneity
- Crystalline defects engineering
- Electron and phonon transport properties optimization
- Growth of complex semiconductors and quantum materials

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