Materials Selection

PARTICLES DETECTOR SUPPORT

proposed solution

objective

- PARTICLE DETECTOR
  - Development of new detectors
  - Study of particle structures and interactions
- SUPPORT FOR PARTICLE DETECTOR
  - Positioning of the silicon chip
  - Allow:
    - Alignment fixtures
    - Carry heat from the silicon sensor to the cooling element
    - Avoid vibrations
    - Elementary particles transmission

Design Requirements

- Function
  - Detector support
- Constraints
  - High stiffness
    - Avoid vibrations
    - Enable the (Si) chip positioning
  - $\text{Support}_{\text{Flexural strength}} \geq \text{Si}_{\text{Flexural strength}}$
  - Precise Machining
  - Dimensions
  - Transparent to elementary particles

- Objectives
  - Max thermal conductivity
  - Max radiation length

- Free variables
  - Material

Constraints

- High Stiffness (D=EI)
  - Avoid vibration
  - Enable the (Si) chip positioning
  - $E_{support} = E_{Si} \rightarrow E_{support}$ ε [100GPa; 200GPa]
- Flexural strength
  - $FS_{Support} \geq FS_{Si} \rightarrow FS_{Support} = 150MPa$
- Machining
  - Precise
  - Vickers Hardness ε [50HV;3000HV]
- Dimensions
  - Thickness fixed at 1.5mm
- Transparent to elementary particles
  - A and Z min

Objectives

- Max thermal conductivity

  –> Max λ [W/Km]

- Max radiation length

$$\frac{1}{X_0} = \frac{4\alpha N_A Z(Z+1) r_e^2 \log(183 Z^{-1/3})}{A}$$

α = fine structure constant (≈1/137)

N_A = Avogadros number ($6.022.10^{23}$/mole)

Z = Atomic number of the traversed material

A= Atomic weight of the traversed material

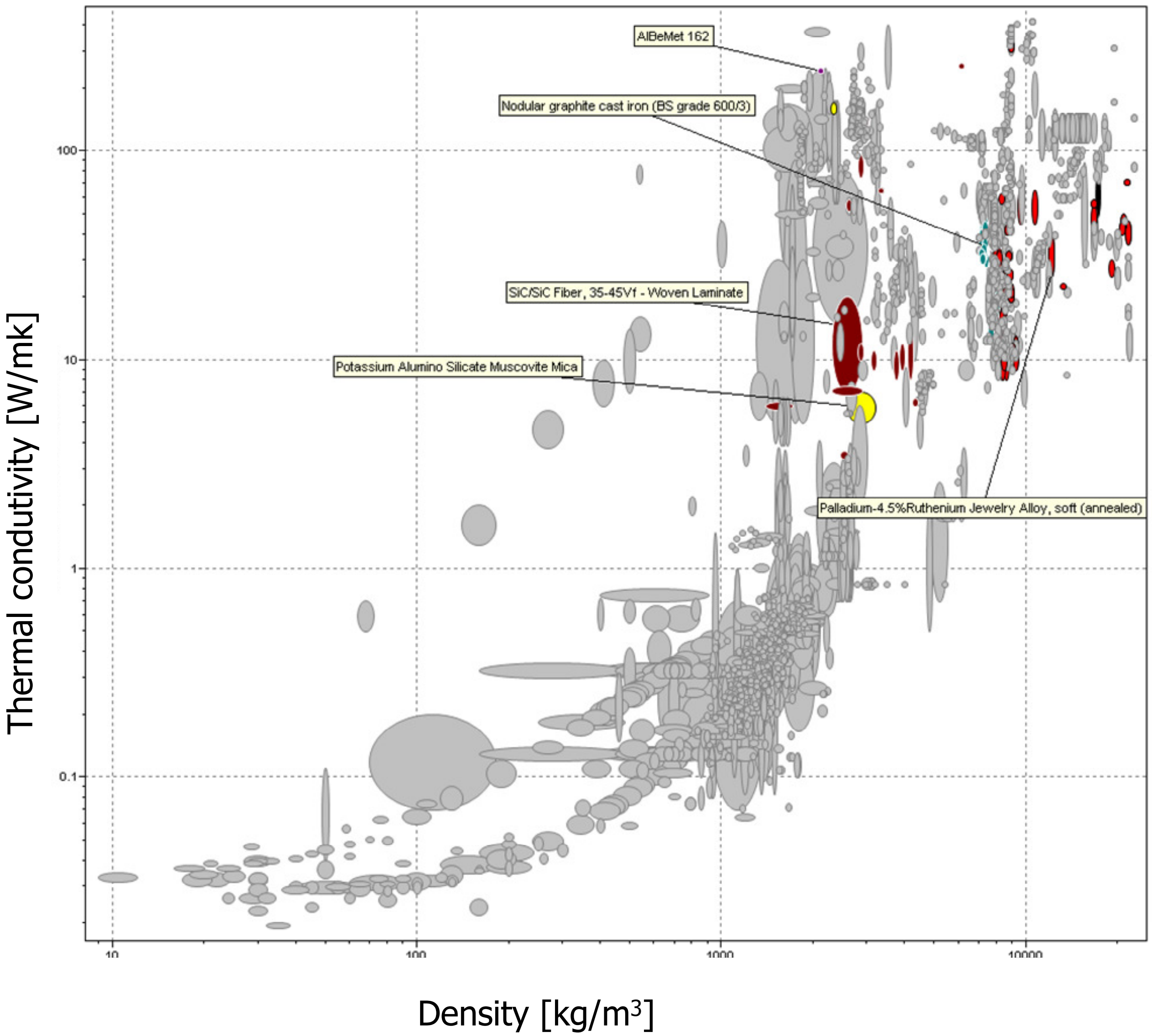
R_e= Electron radius ($2.818.10^{-13}$ cm)

–> Z (atomic number) as small as possible

Variables-Results

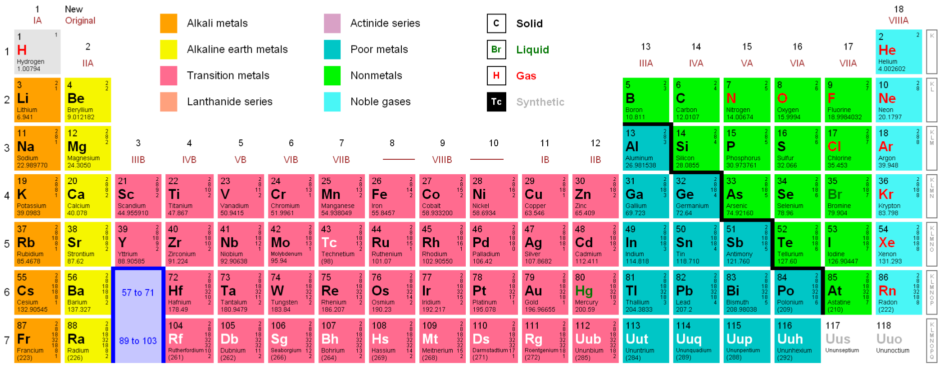
- Limit Stage:
  - Stiffness
  - Tensile Strength
  - Hardness
- Graph Stage:
  - Density→ transparent?

No transparent solution



Results

- Transparent → lower Z than Al→ Li, Mg, Na and B, C, Be.

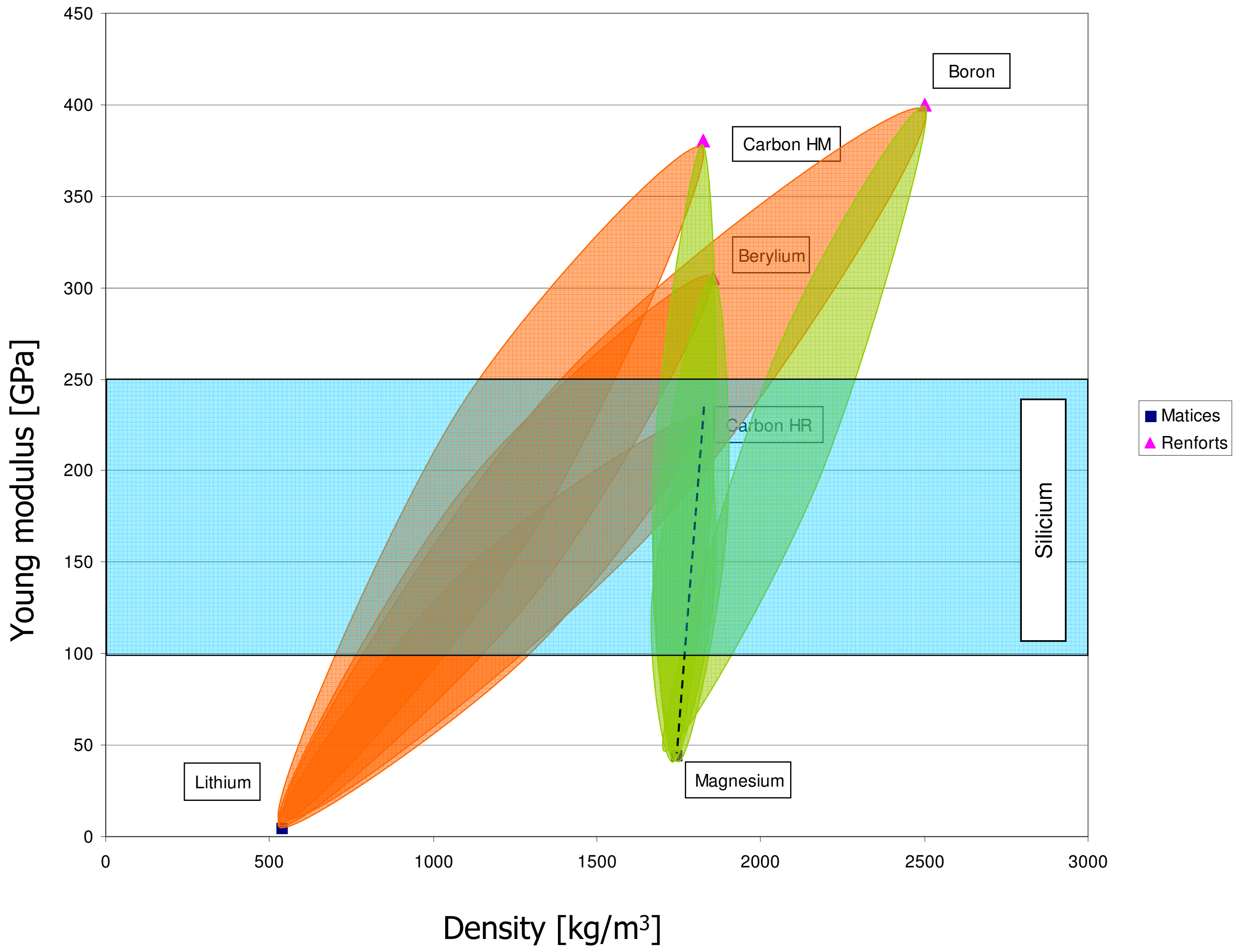


- 2 matrix
- 3 reinforcements

	Density [kg(m3]	Atomic number	Atomic weight [gr/mol]	Radiation lenght	Y. Modulus [Gpa]	tensile strenght [Mpa]	Hardness [HV]	Therm. Conduc [W/m.K]	CTE [ppm/K]
Lithium (pure)	535	3	6.941	196.95	4.9	2.5	0.4	80	55
Magnesium (pure)	1740	12	24.305	58.65	45	200	40	152.5	0.9
Beryllium (fiber)	1854	4	9.012	156.53	305	965	300	185	5.5
Boron (fiber)	2500	5	10.81	127.16	400	2250	900	19	5.5
Carbon (fiber HR)	1820	6	12.011	102.25	230	4650	700	100	0.3
Carbon (fiber HM)	1825	6	12.011	102.25	380	2405	700	100	0.3
Diamond	3500	6	12.011	102.25	1100	2880	4500	300	1.0
Silicon	2330	14	28.086	50.94	160	170	1000	160	3.0

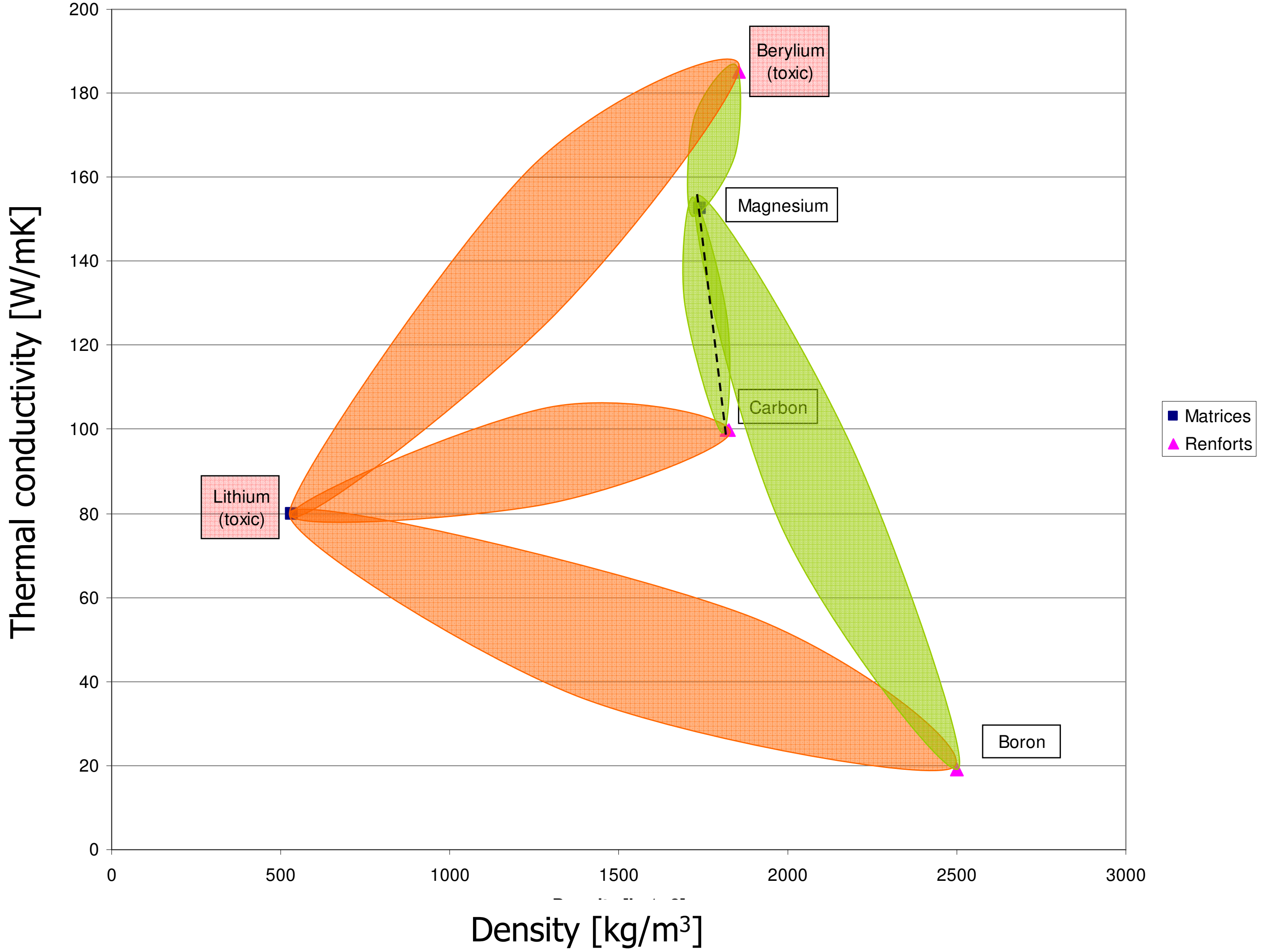
Results

- Young modulus close to Silicium's



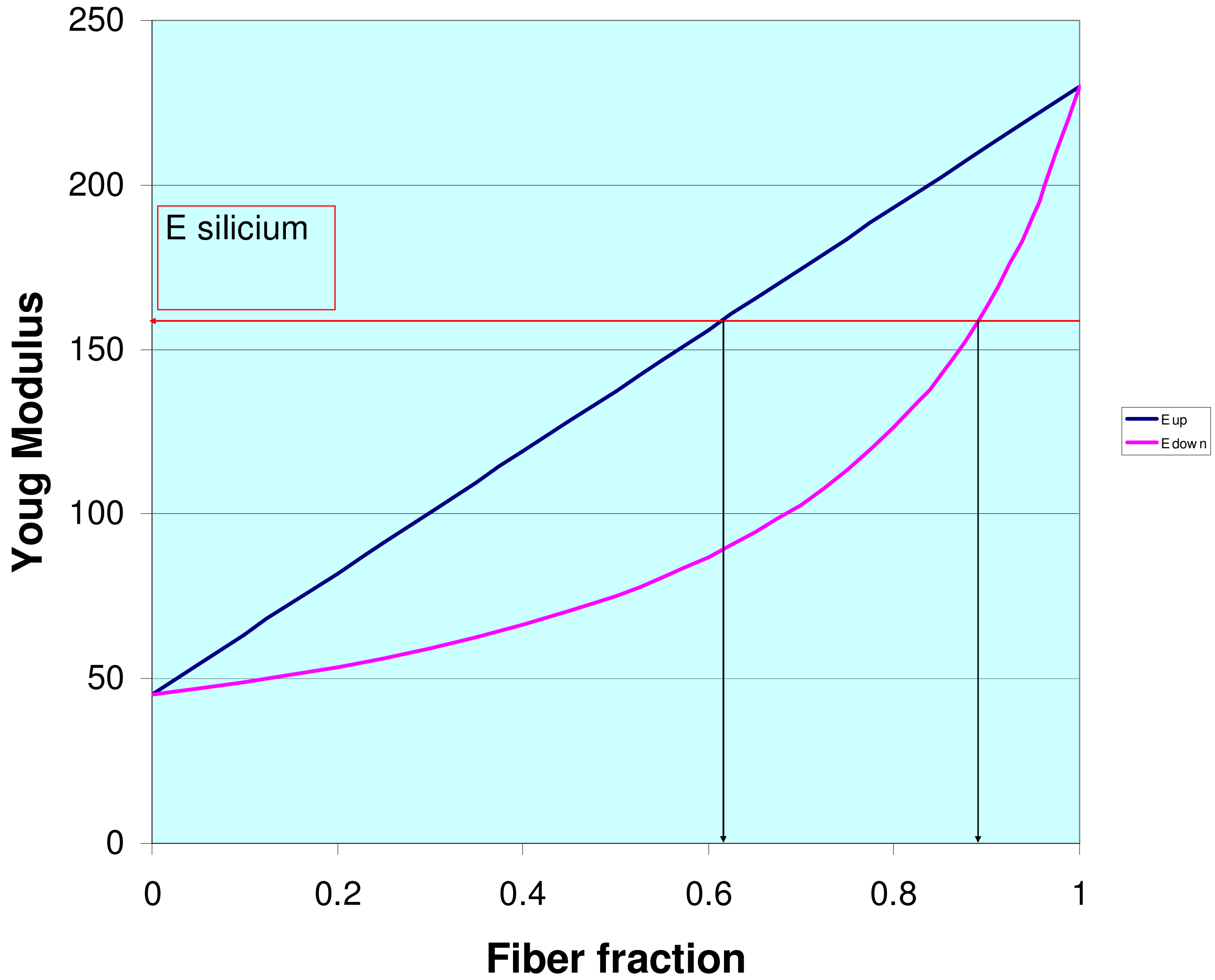
RESULTS

- Thermal conductivity optimization



RESULTS

- Magnesium reinforced with carbon fibers



RESULTS

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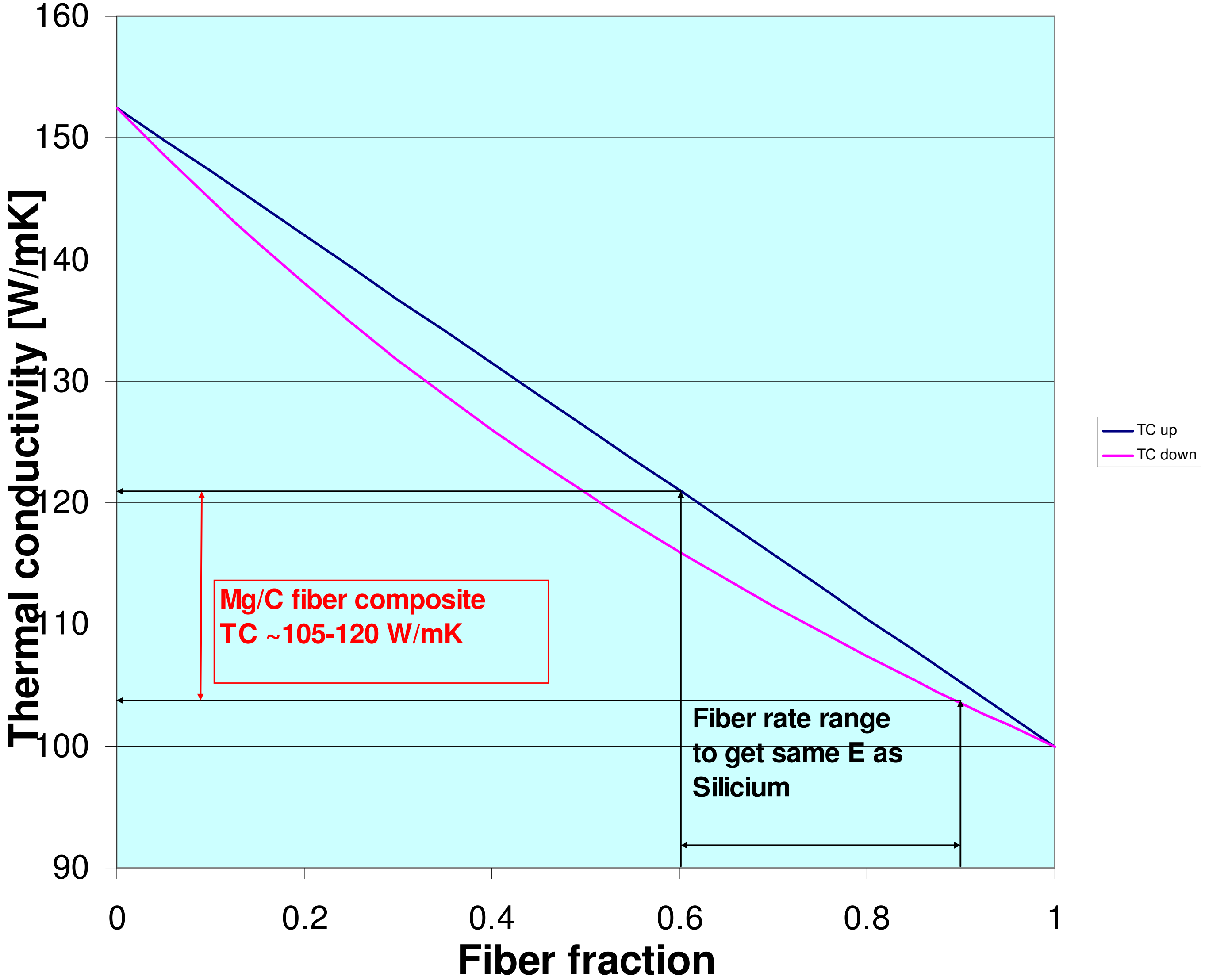
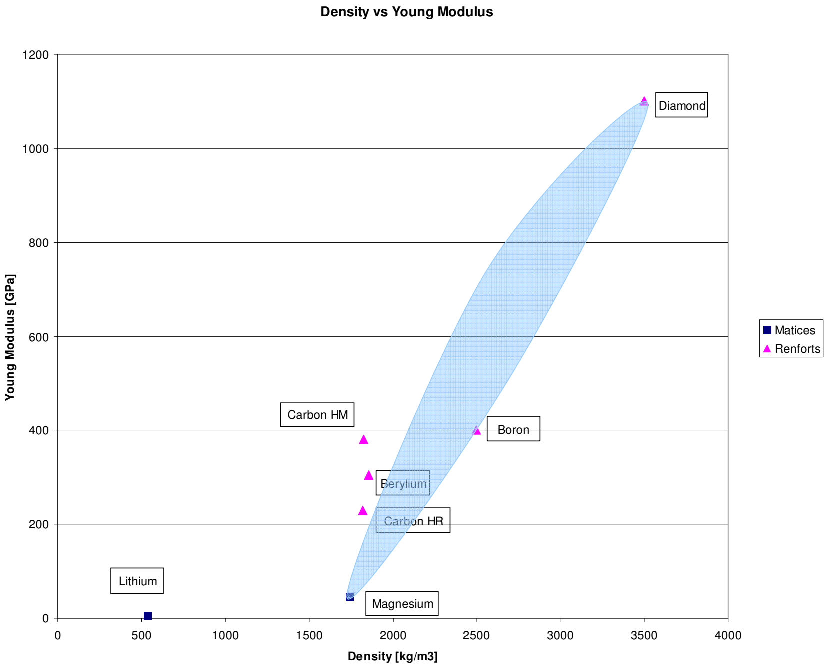
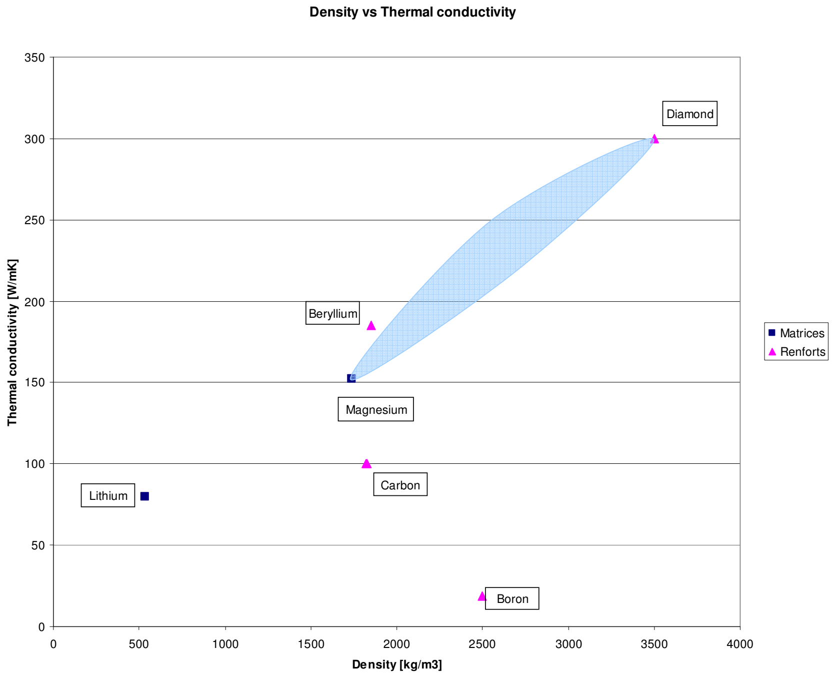


RESULTS

- Diamond exclusion
  - Low reinforcement content→ correct Young modulus
  - Low reinforcement content→ thermal conductivity low
  - Difficult precise machining





Conclusions

- Two possibilities:
  - Magnesium carbon reinforced
  - Magnesium boron reinforced
- Magnesium reinforced with carbon fibers
  - 60% carbon fibers
- Characteristics
  - High stiffness: $E=150MPa=E_{Si}$
  - Possible machining
  - Transparent to elementary particles
  - Thermal conductivity= 120 [W/mk]
  - High radiation length