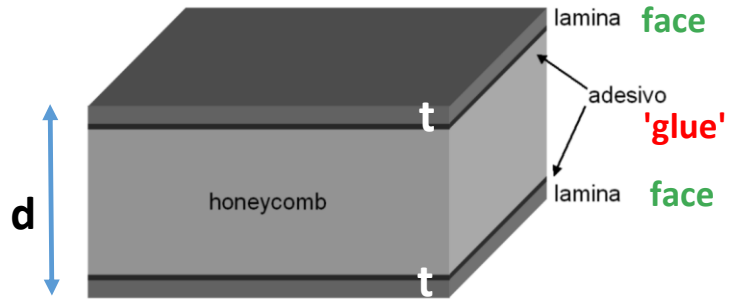
Efficient panels with sandwich construction: elasticity

$$E_{sand} \cong \frac{6t}{d} \cdot E_f = 3 \cdot \frac{2t}{d} \cdot E_f$$



E max for a fibrous composite

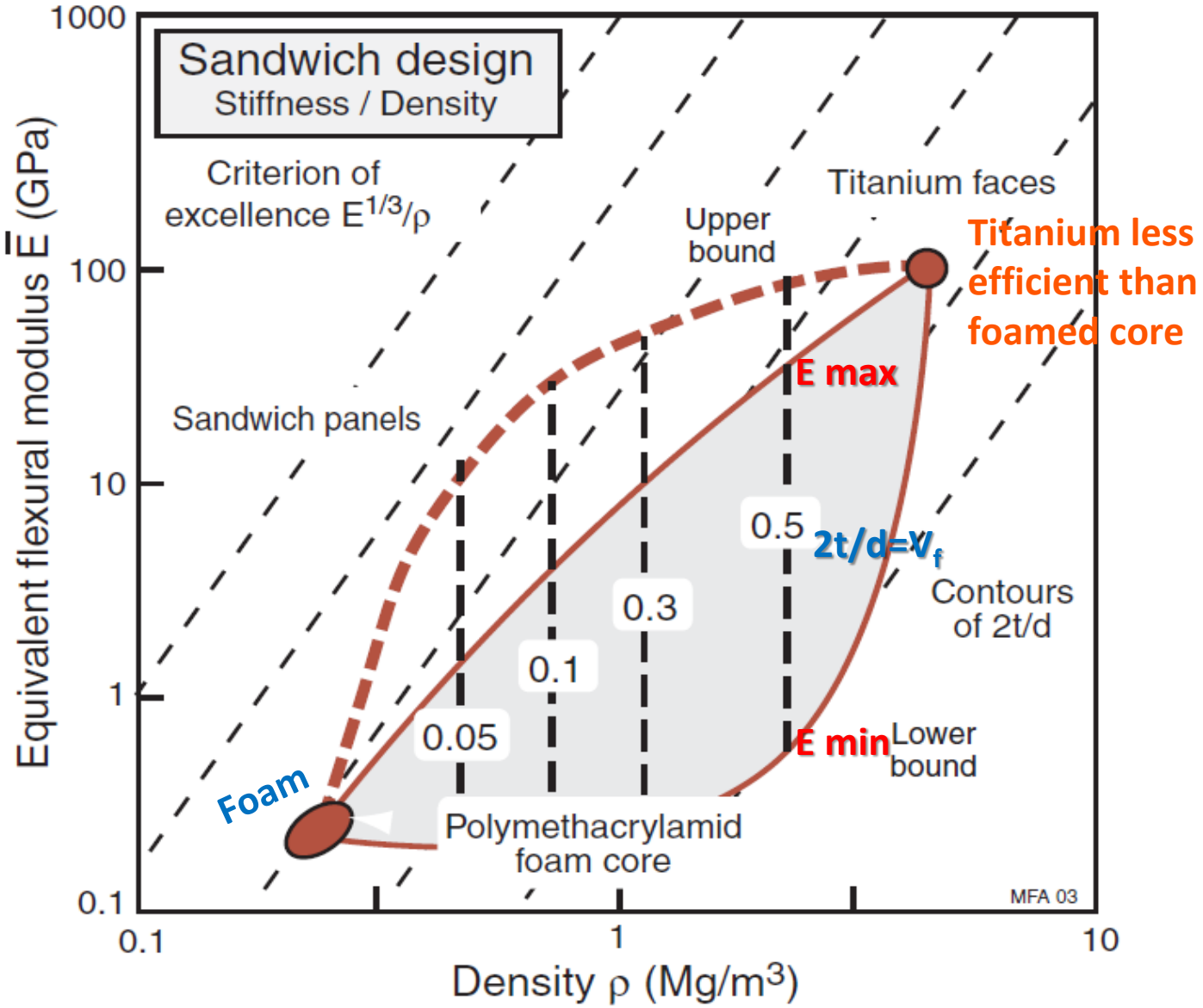
$$E_{comp} = \frac{2t}{d} \cdot E_f + \left(1 - \frac{2t}{d}\right) \cdot E_c \cong \frac{2t}{d} \cdot E_f$$

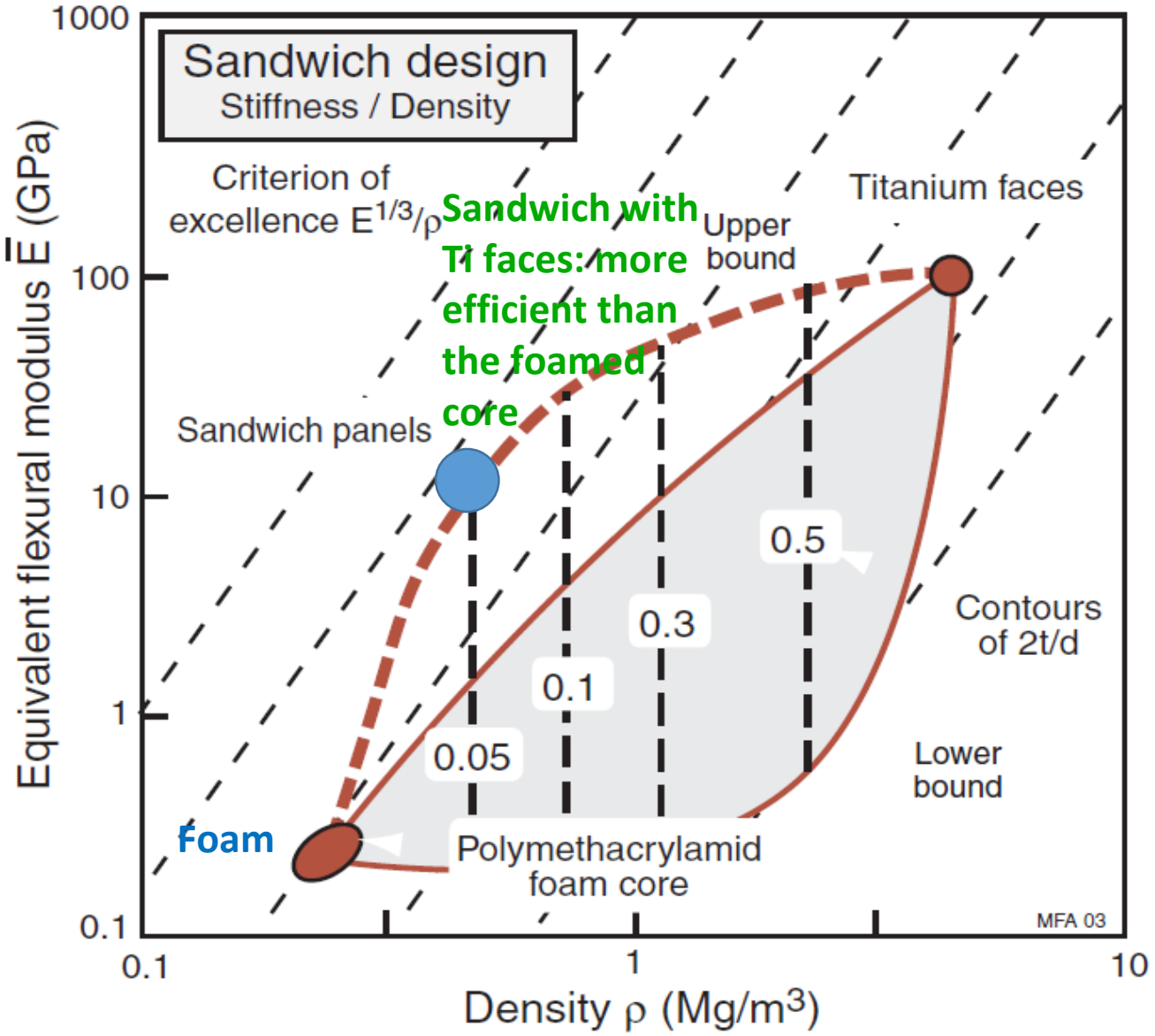
$$\rho_{sand} = \rho_{comp} = \rho \rightarrow$$

$$\boldsymbol{I_{sand}} = \frac{E_{sand}^{\frac{1}{3}}}{\rho} = \frac{\left(3 \cdot \frac{2t}{d} \cdot E_f\right)^{\frac{1}{3}}}{\rho} = 3^{\frac{1}{3}} \cdot \frac{\left(\frac{2t}{d} \cdot E_f\right)^{\frac{1}{3}}}{\rho} = 3^{\frac{1}{3}} \cdot I_{comp}$$

$$= \mathbf{1.44} \cdot \boldsymbol{I_{comp}}$$

Sandwich: bending efficiency with a 40% increase compared to that of a composite with the same materials and same relative quantities


Sandwich design
Stiffness / Density
Criterion of excellence $E^{1/3}/\rho$
Titanium faces
Upper bound
Titanium less efficient than foamed core
E max
Sandwich panels
0.5
2t/d=v_f
0.3
Contours of 2t/d
0.1
0.05
E min
Lower bound
Foam
Polymethacrylamid foam core
MFA 03
Equivalent flexural modulus $\bar{E}$ (GPa)
Density ρ (Mg/m^3)
1000
100
10
1
0.1
0.1
1
10



Optimum= thin Ti faces (t=5% d)

Ottimo=pelli sottili di Ti (t=5% d)

Strength of sandwich panels (approx.)

$$\sigma_{f,sand} \cong \frac{4t}{d} \cdot \sigma_{f,face} = 2 \cdot \frac{2t}{d} \cdot \sigma_{f,face}$$

Strength of fibrous composite

$$\sigma_{f,comp} \cong \frac{2t}{d} \cdot \sigma_{f,face}$$

$$\rho_{sand} = \rho_{comp} = \rho \rightarrow$$

$$\boldsymbol{I_{sand}} = \frac{\sigma_{f,sand}^{\frac{1}{2}}}{\rho} = \frac{\left(2 \cdot \frac{2t}{d} \cdot \sigma_{f,face}\right)^{\frac{1}{2}}}{\rho}$$

$$= 2^{\frac{1}{2}} \cdot \frac{\left(\frac{2t}{d} \cdot \sigma_{f,face}\right)^{\frac{1}{2}}}{\rho} = 2^{\frac{1}{2}} \cdot I_{comp} = \mathbf{1.41} \cdot \boldsymbol{I_{comp}}$$

Sandwich: 40% improvement also in terms of strength [compared to density]

"Use less, use better" approach
Some applications?
https://www.linkedin.com/pulse/stone-aluminum-honeycomb-board-story-he-ding-marbles-and-stones/
[thanks to Mr Hemasian]



"Green, environmental protection, and energy-saving curtain wall materials: the honeycomb panels used in stone aluminum honeycomb panels are all ***aluminum*** *structures, which is a* ***green****, environmental protection and energy-saving new building materials, and is honored as the best curtain wall building materials in the 21st century;* ***The thickness of the stone used is between 3-8mm, which is one-half of the thickness of the traditional stone****."*