DECHEMA FORSCHUNGSINSTITUT

4 Point Bending at High Temperatures with in-situ Acoustic Emission Measurement

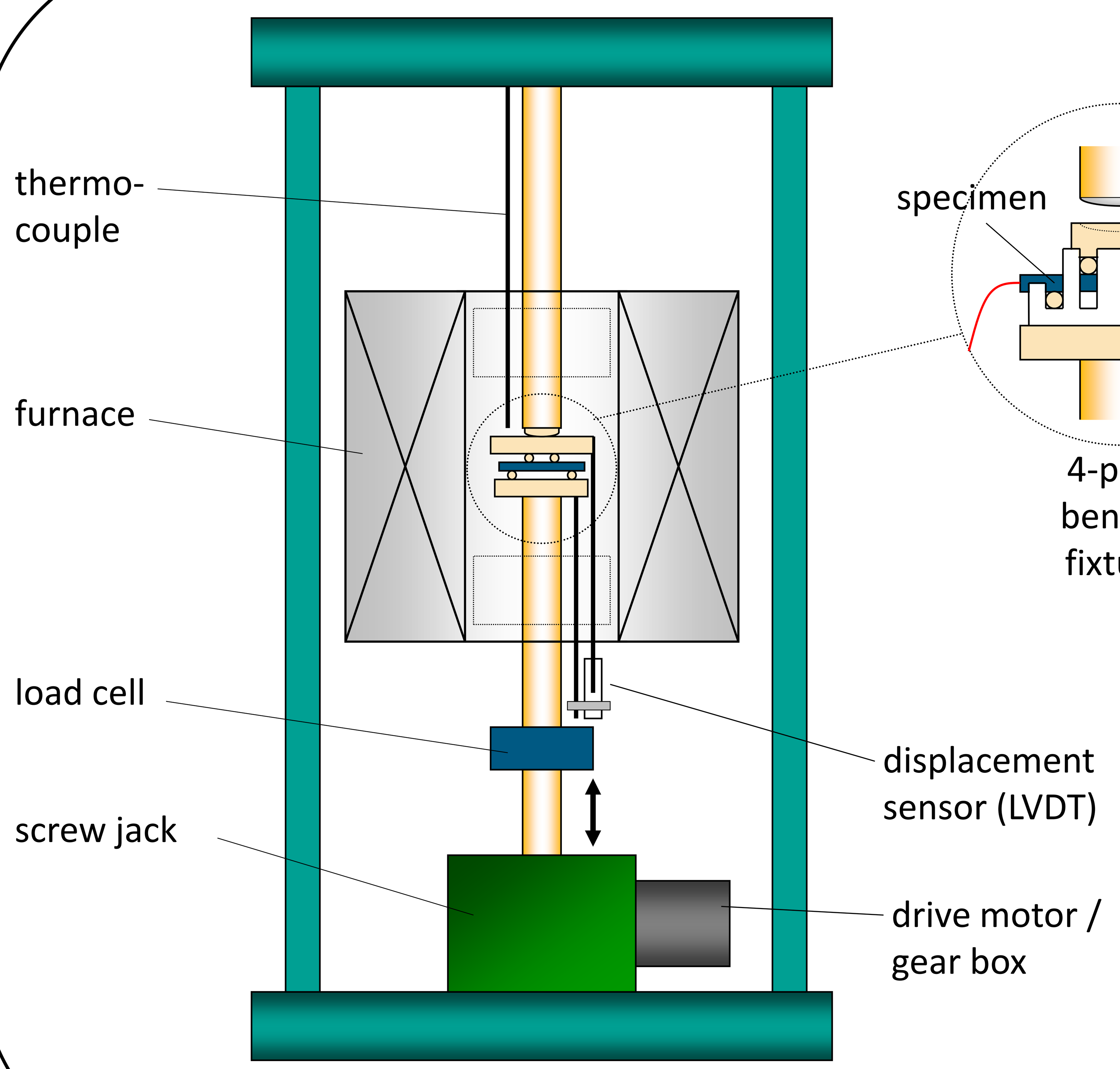


Fig. 1: Schematics of the 4-point bending apparatus.

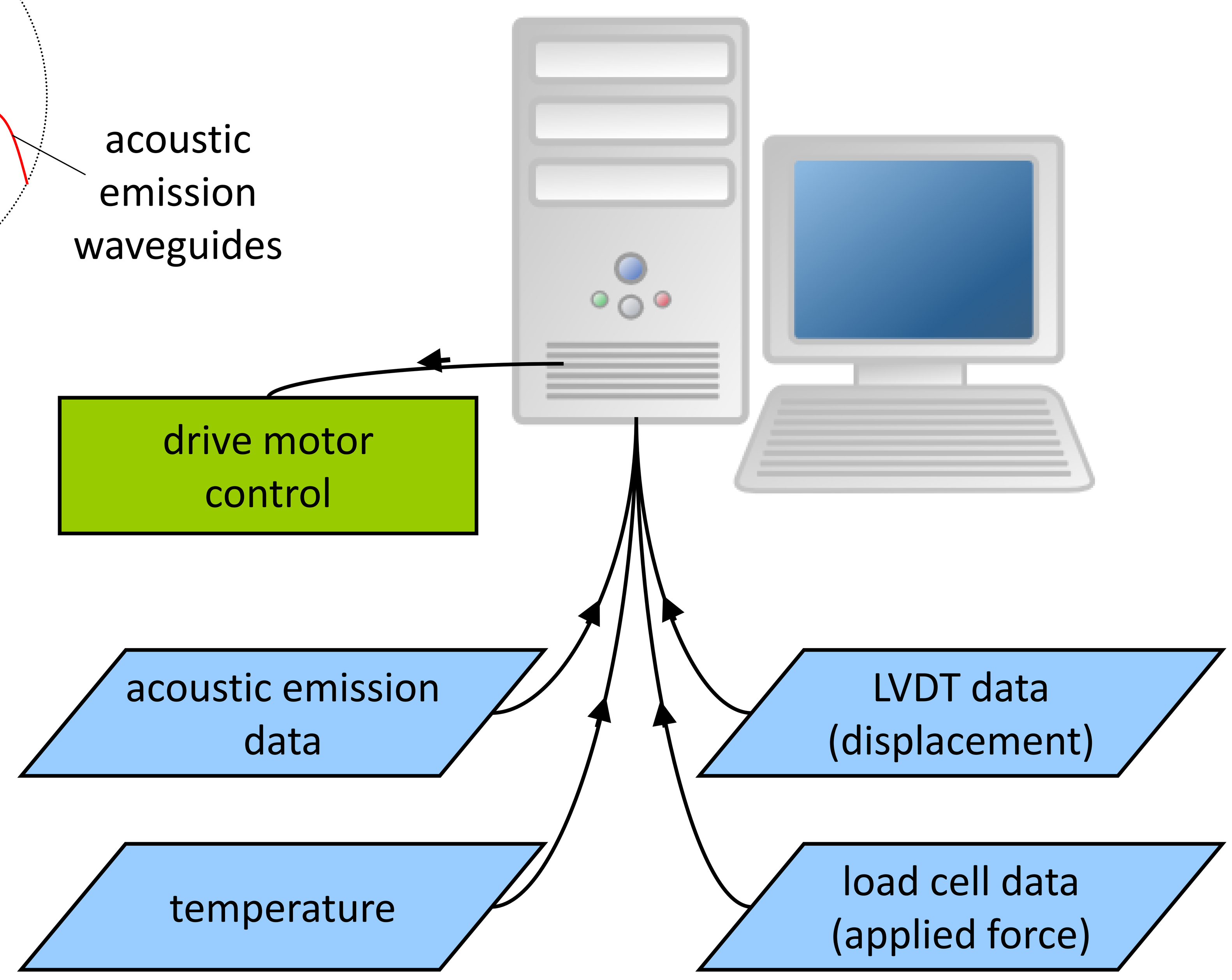
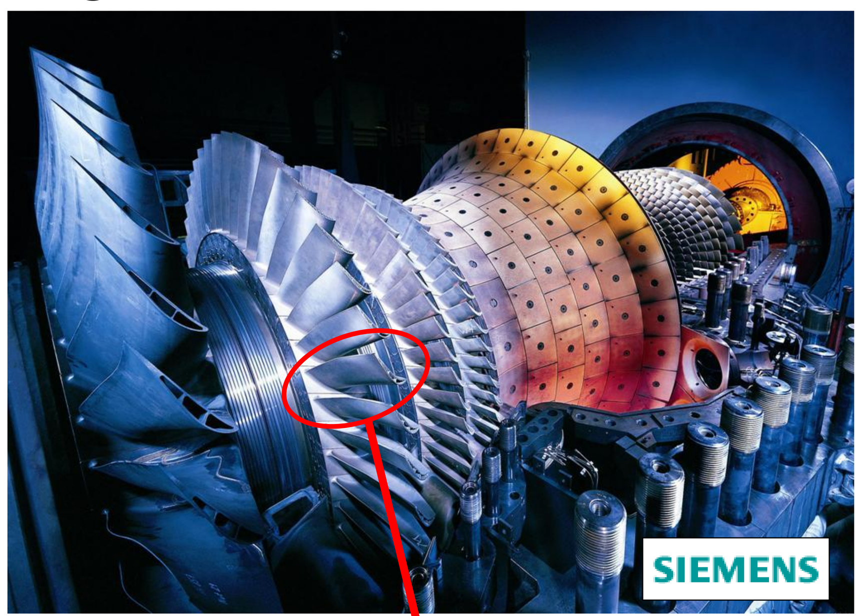


Fig. 2: Schematics of the data acquisition system.

Example Application: Thermal Barrier Coatings 4-Point Bending at Room Temperature after Pre-Oxidation

Fig. 3: Gas turbine.



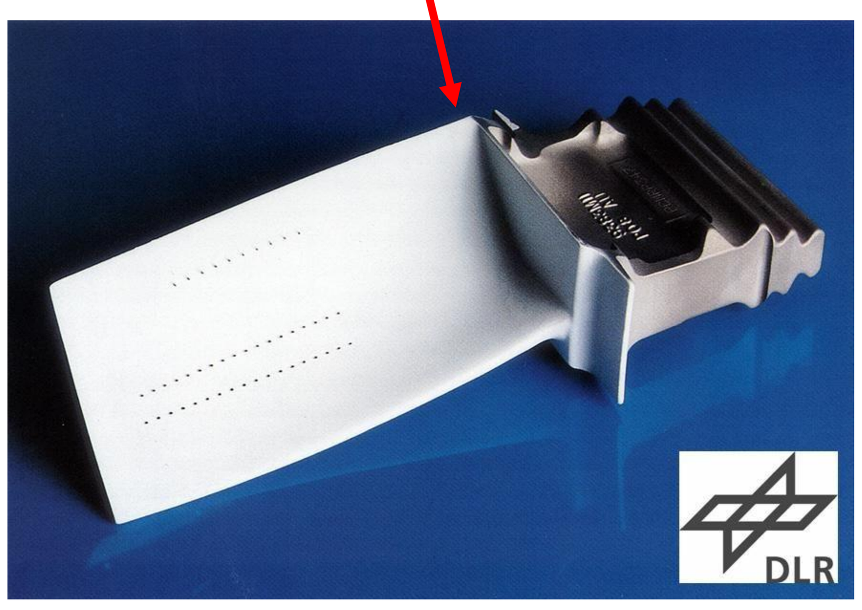


Fig. 4: Turbine blade with ceramic thermal barrier coating (TBC).

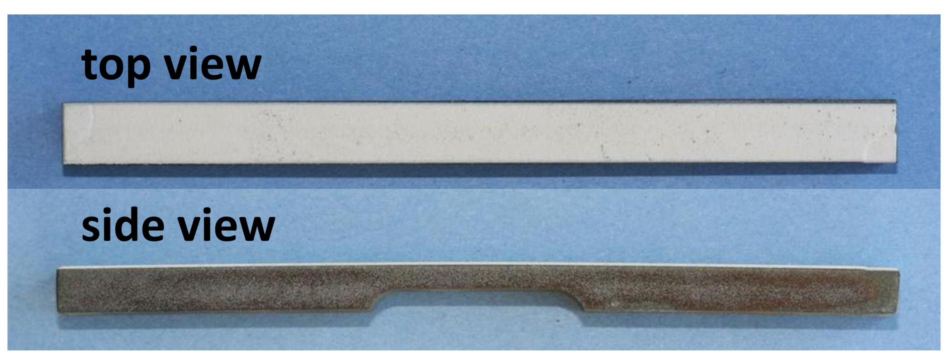
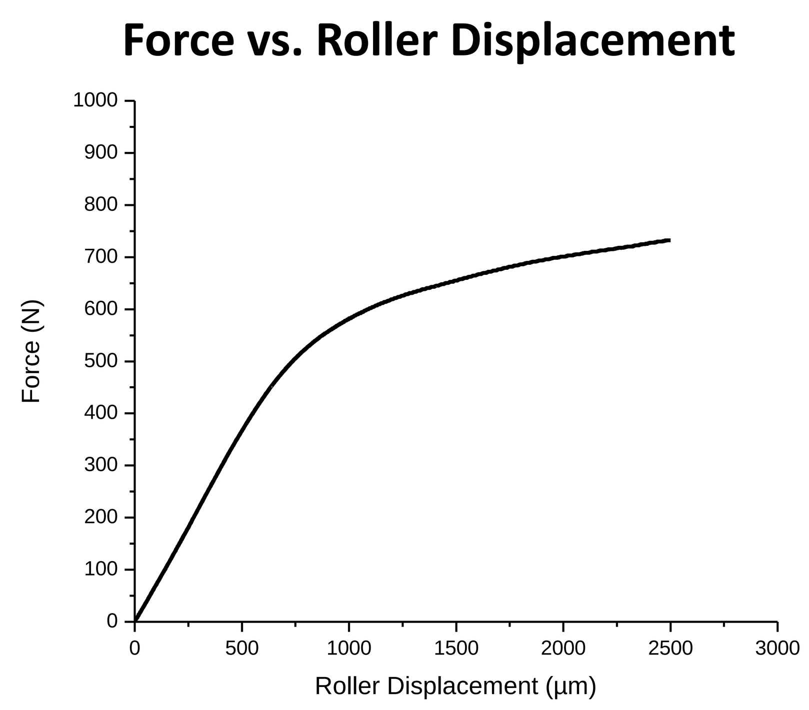


Fig. 5: TBC specimen for 4-point bend testing.



Elastic Strain:

$$\varepsilon = \left(\frac{l-a}{2}\right)\cdot\left(\frac{B_1 \cdot y \cdot d}{B_2 \cdot C + (B_2 - B_1)\cdot D}\right)$$

$$C = \frac{la^2}{8} - \frac{a^3}{12} - \frac{l^3}{24} \qquad D = \left(\frac{l-a}{2}\right)\cdot\left(\frac{lb}{4} - \frac{ab}{4}\right)$$

B_1 and B_2 are bending stiffnesses

$B = E_{sub}I_{sub} + E_{bc}I_{bc} + E_{tc}I_{tc}$

y is specimen thickness in thin part

d is roller displacement

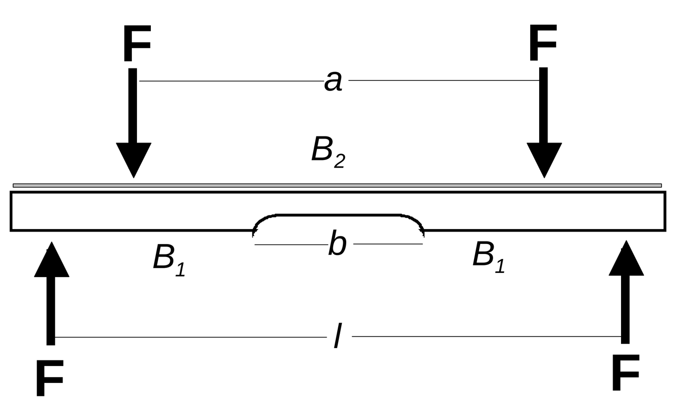


Fig. 6: Typical force vs. displacement curve and equations for conversion of displacement to strain for depicted sample geometry.

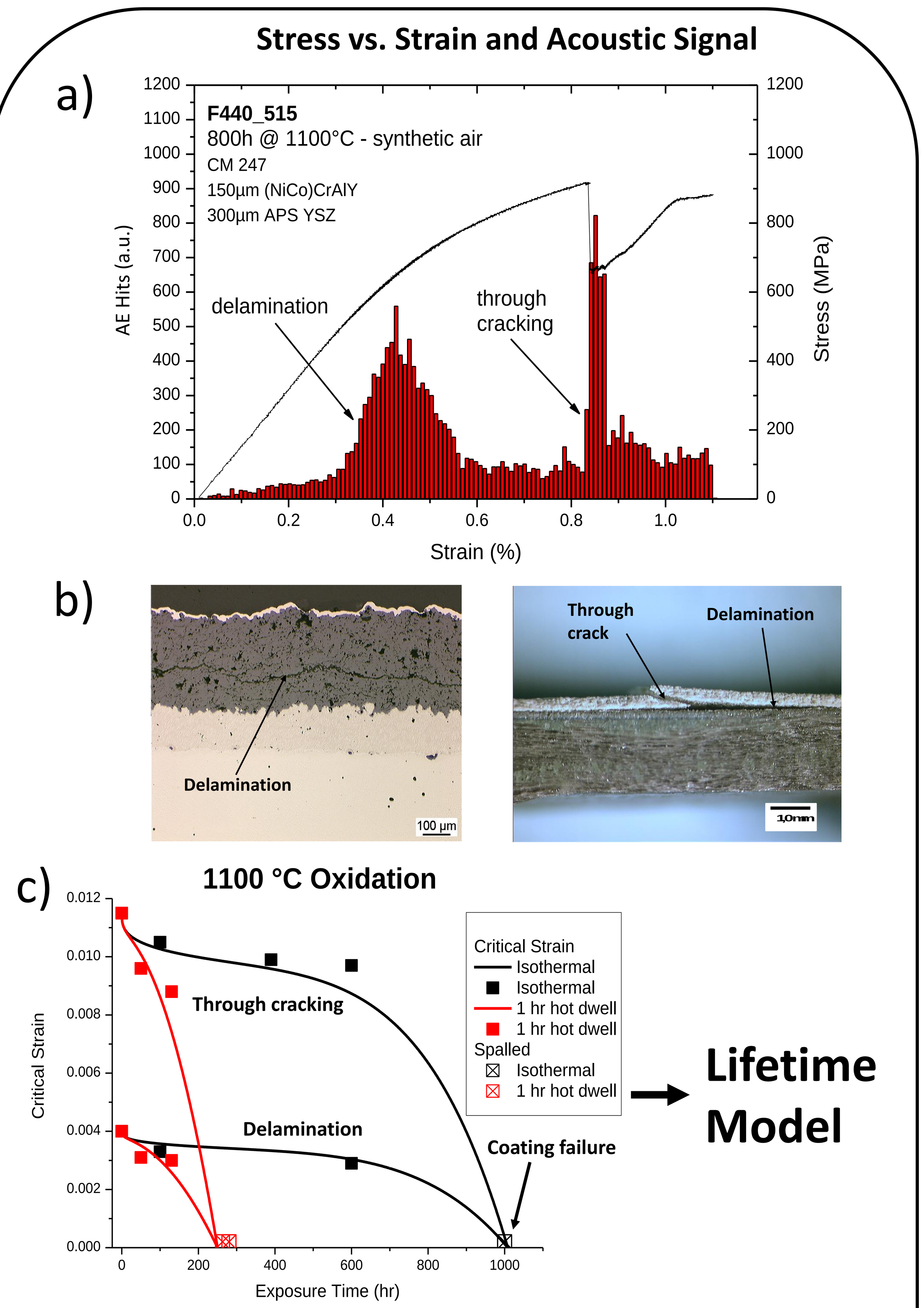


Fig. 7: Measurement curve (stress vs. strain) and corresponding acoustic emission signal (a) of TBC specimen. Both delamination and through cracking modes can be detected with acoustic emission (b). Critical strain data can be used for lifetime modeling (c).