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MECHANICAL PROPERTIES & FAILURE ANALYSIS OF CERAMIC AND GLASS MATERIALS – KEVIN STRONG

Ceramics Expo 2023

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CERAMIC CAREER BACKGROUND

- B.S. Ceramic Engineering – Alfred University (2008)
- Post-Bachelor at Oak Ridge National Laboratory (2008-2009)
  - Mechanical testing of armor ceramics and glasses
- Ph.D. Materials Science and Engineering - University of Washington (2015)
  - Processing and Mechanical properties of Si_3N_4/SiC composites.
- Sandia National Laboratories (2015 – Present)
  - Subject Matter Expert of Ceramic and Glass Materials (focus on mechanics/mechanical properties)
  - Job Duties: Failure Analysis of ceramic and glass components (fractography), design and testing of ceramic and glass components under realistic environments, research slow crack growth phenomena / delayed failure

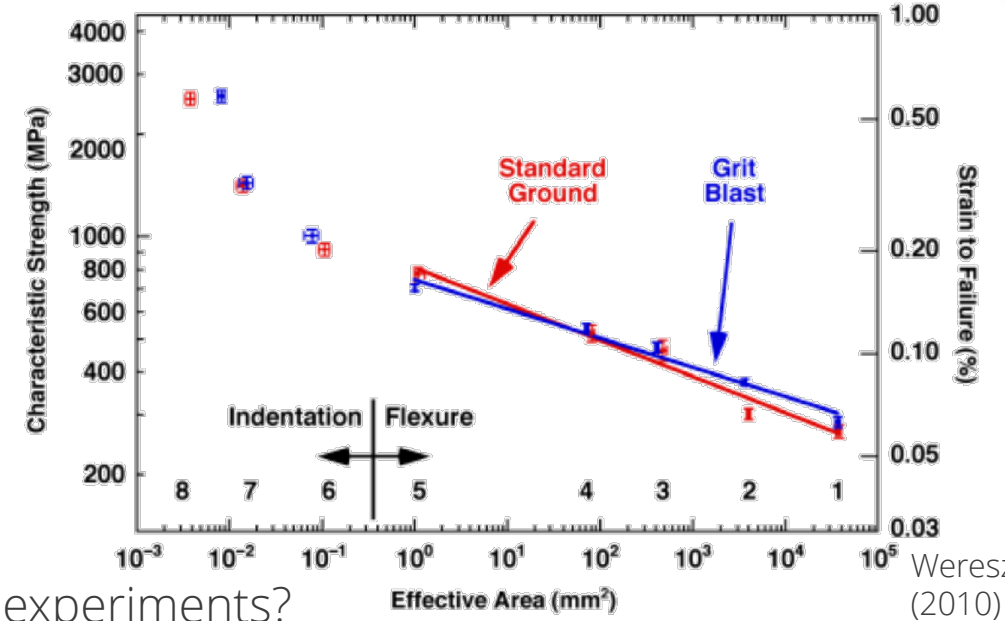
ASSESSING STRENGTH AND RELIABILITY

Use statistical approaches (Weibull) to predict strength of ceramics parts from standard laboratory experiments.

Strength size scaling works if:

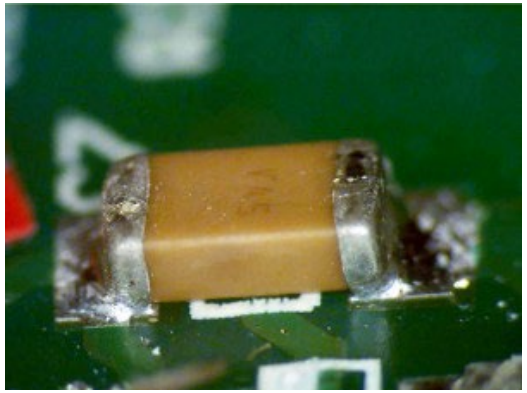
1) flaw size and size distribution are the same
2) know the applied stress and stressed area

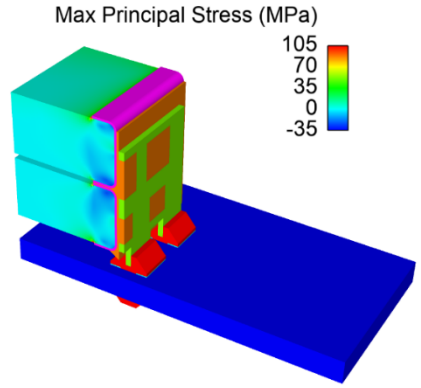
$$P_f = 1 - exp\left[-\left(\frac{\sigma}{\sigma_O}\right)^m\right] \qquad \sigma_B = \left(\frac{k_{AA}A_A}{k_{AB}A_B}\right)^{1/m} * \sigma_A$$



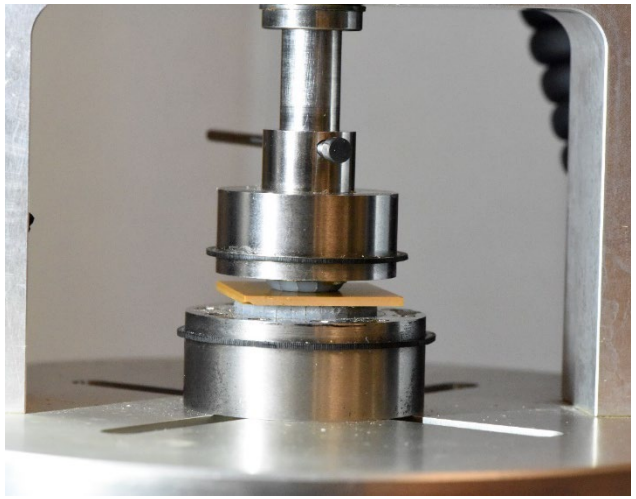
Wereszczak (2010)

How do you predict strength and reliability of real ceramic parts in components…





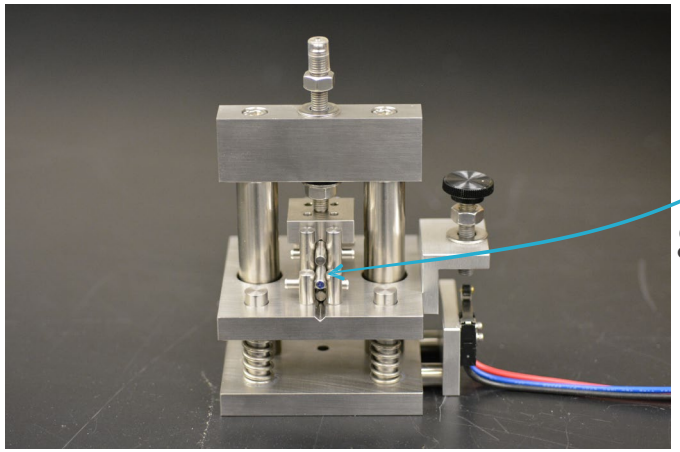
from laboratory experiments?



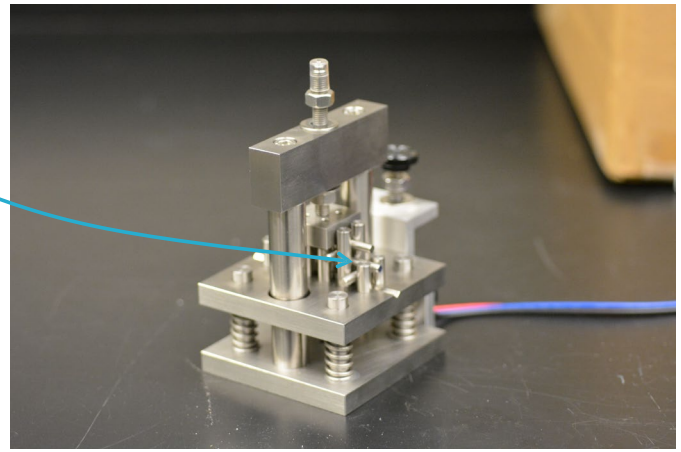
DELAYED FAILURE PREDICTIONS

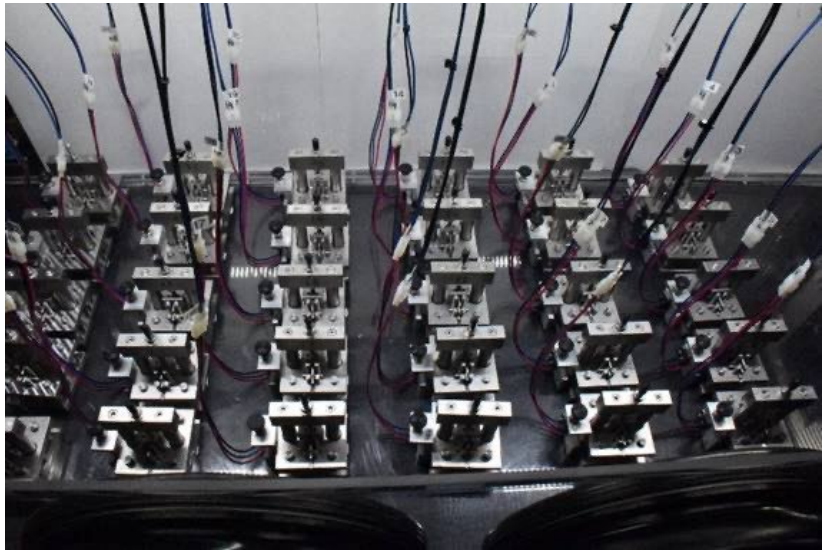
Need to account for delayed failure in ceramics for long term reliability.

Static Fatigue Fixtures



Bend bar goes here





Weibull Parameters

$\sigma_0 = 186$ MPa, $\rho = 4.654$

Slow Crack Growth Parameters

$A = 0.00183$ m/s, $n = 90.7$

$$P_f = 1 - \exp\left(-\left\{\frac{\left[\frac{A(n-2)Y^2\sigma_f^2 t_f}{2K_{Ic}^2}+1\right]^{\frac{1}{n-2}}\sigma_f}{\sigma_0}\right\}^{\rho}\right)$$

Measured Delayed Failure Times