Mechanical and Optoelectronic Response of GaN Micropillars under Uniaxial Microcompression

Adviser: Dr J.C. Huang
Dr J.H. Hsu
Dr S.R Jian

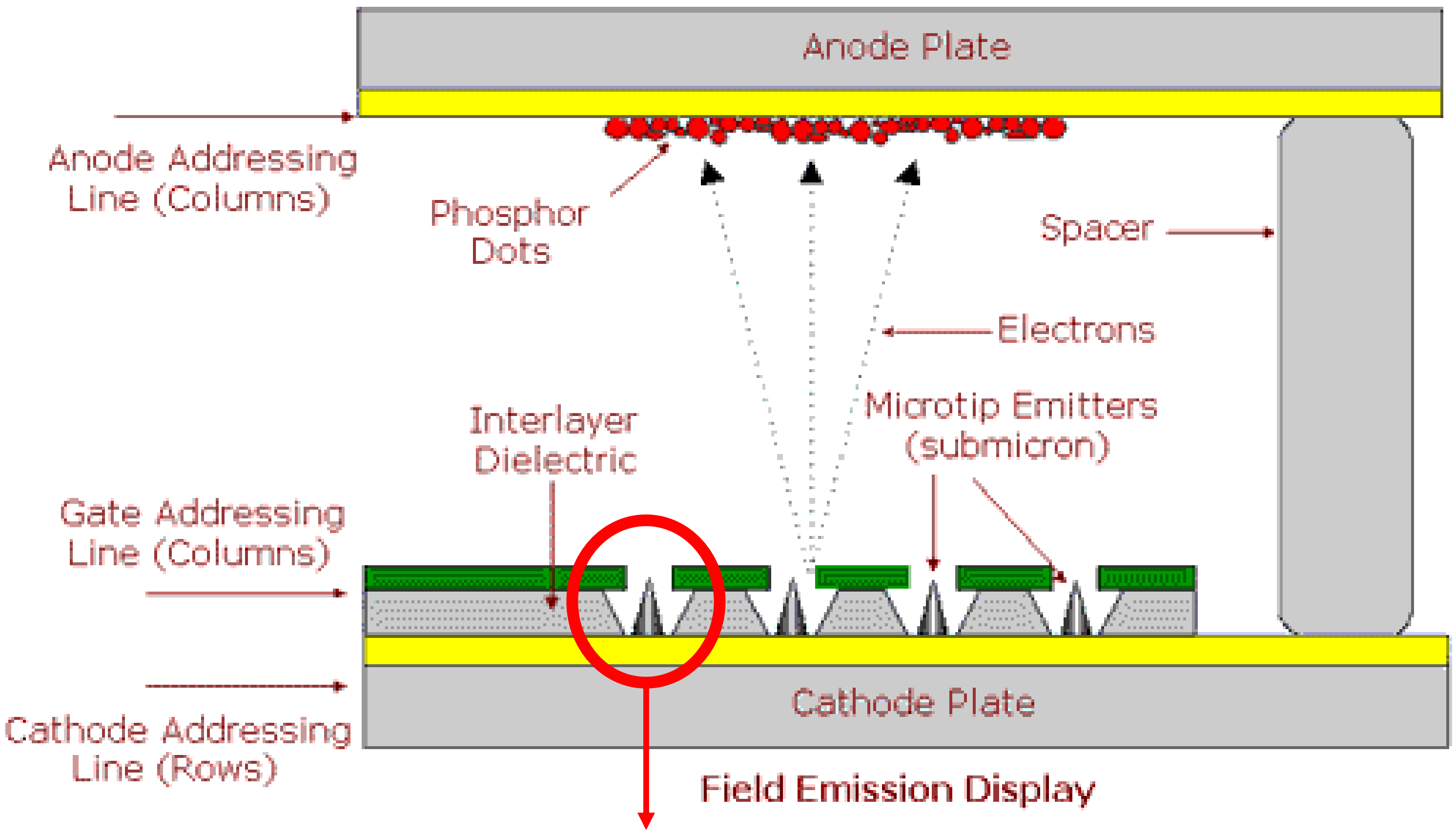
Student: Welson T.H. Sung

Introduction

- Advantages of single crystal GaN
  - Lower energy exhaust （single crystal）
  - Easy changing wide band gap (Doping, 3.39 eV)
  - Avoid quantum confined stark effect (non-polarity)
  - One dimension cylindrical geometry confinement

- Motivation
  - Contact loading during processing or packaging can significantly degrade the performance of the mechanical characteristics and optoelectrical performance. By using the focus ion beam to prepare one dimensional micro pillars and the nanoindentation system to stimulate the contact loading, we can measure the influence of the contact loading on above performances by using the TEM, cathodoluminescence, Raman and photoluminescence.

Application of one dimensional lighten materials: Flat panel field emission displays (FED)

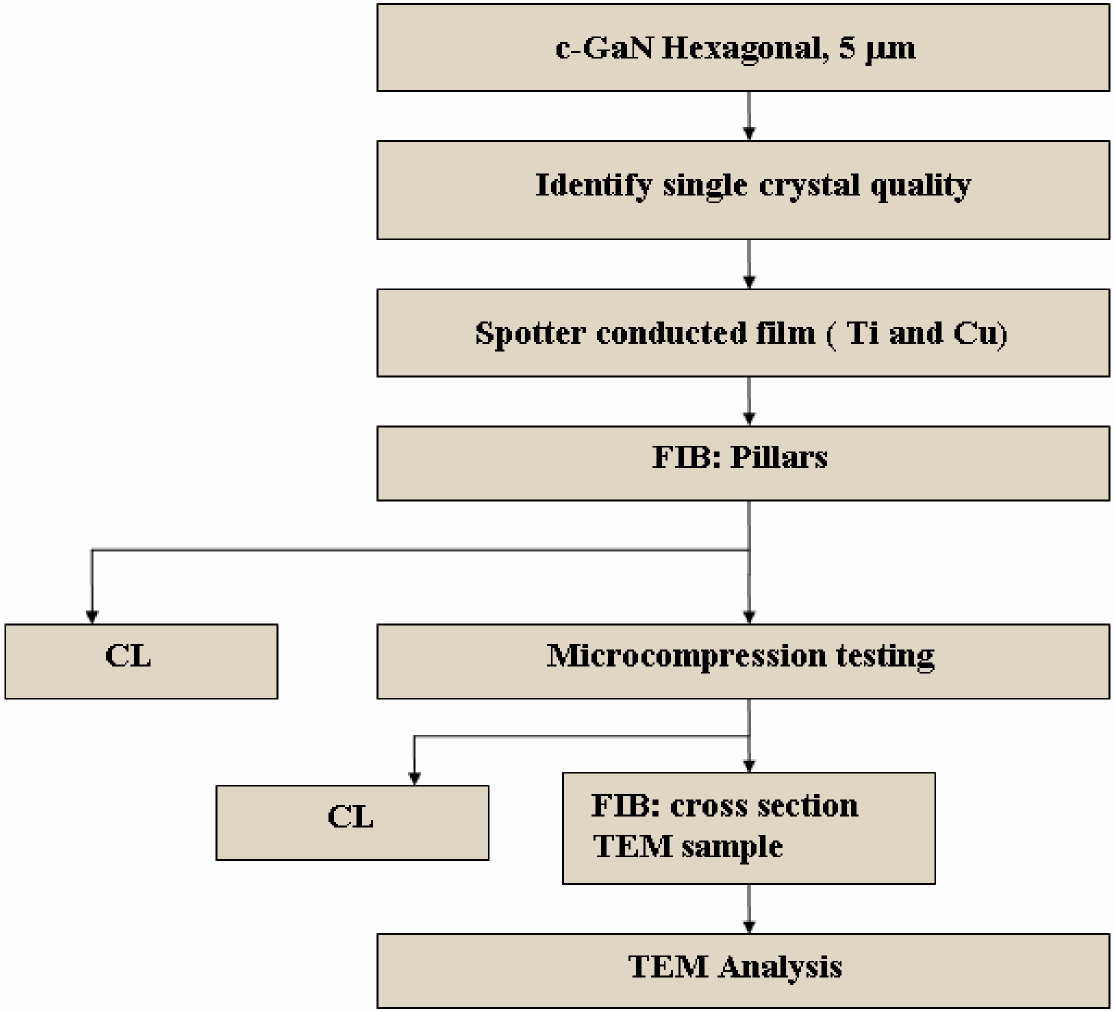


Field Emission Display

Carbon nanotubes: ~4.5 eV, GaN: 2.7-3.3 eV

http://www.meko.co.uk/fed.shtml

Experimental procedure



c-GaN Hexagonal, 5 µm

Identify single crystal quality

Spotter conducted film (Ti and Cu)

FIB: Pillars

CL

Microcompression testing

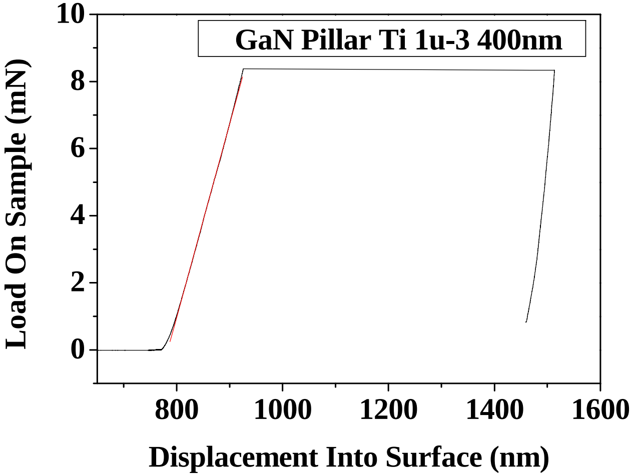
CL

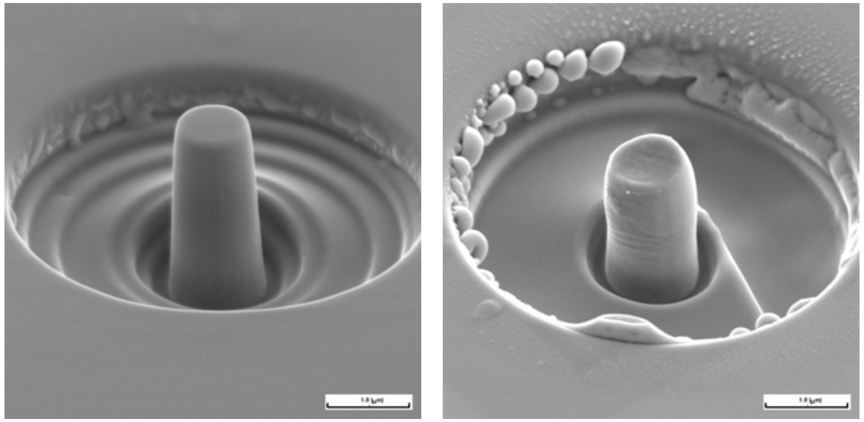
FIB: cross section
TEM sample

TEM Analysis

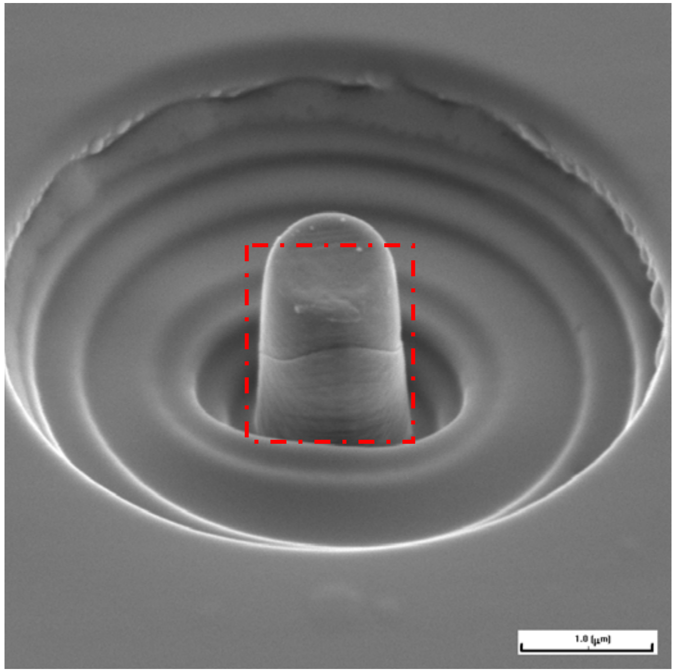
c-GaN micro pillars compression: 400 nm

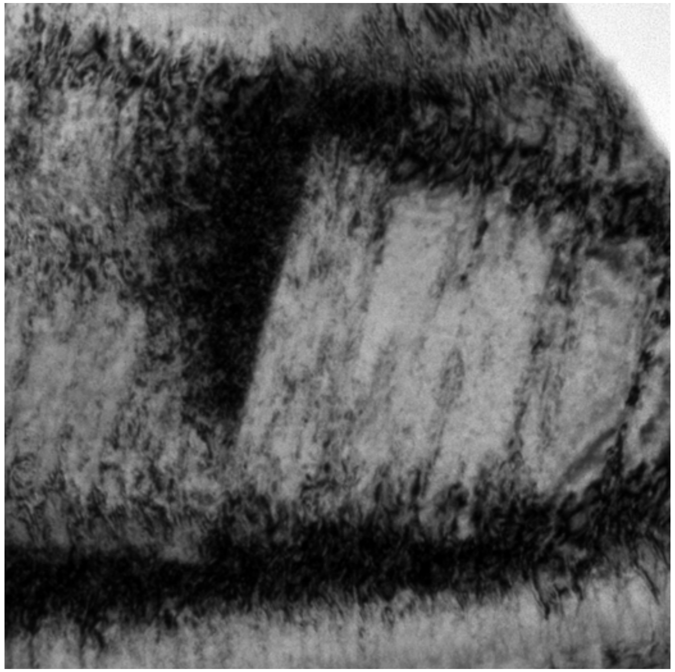
- Diameter: 1017 nm
- Height: 2234 nm
- Taper: 3.00°
- Modified E: 224 GPa
- Goal depth: 400 nm (17.9%)
- Strain rate: 10^{-3} s^{-1}





TEM analysis





Plastic deformation mechanism

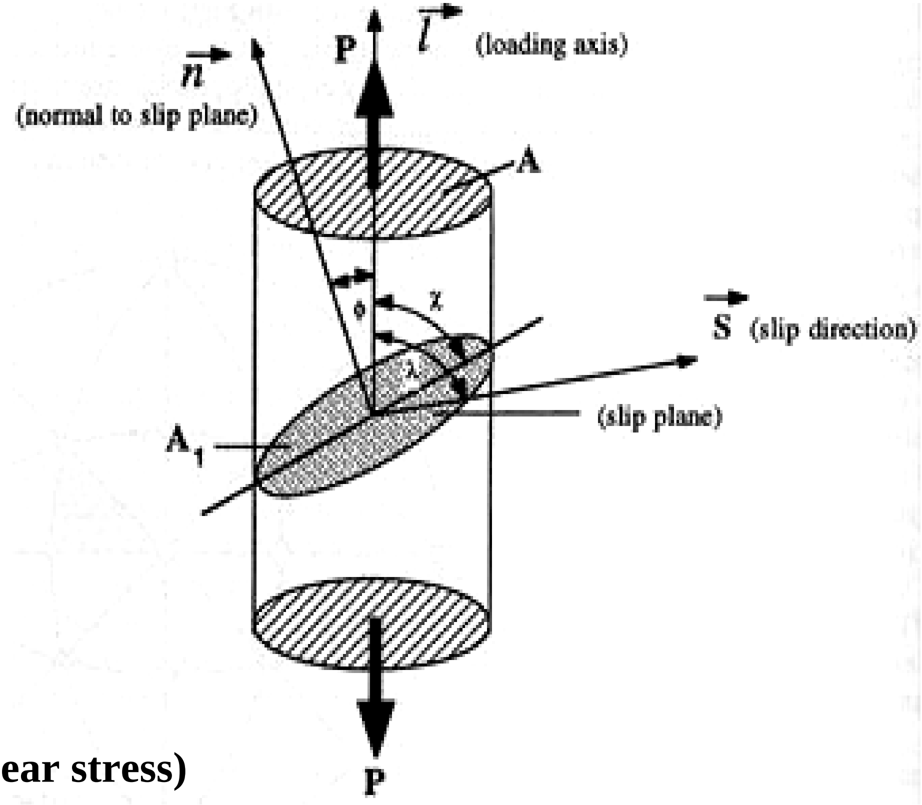
- Dislocation theory

$$\sigma = \frac{P}{A}$$

$$\tau = \sigma \cos\phi \cos\lambda$$

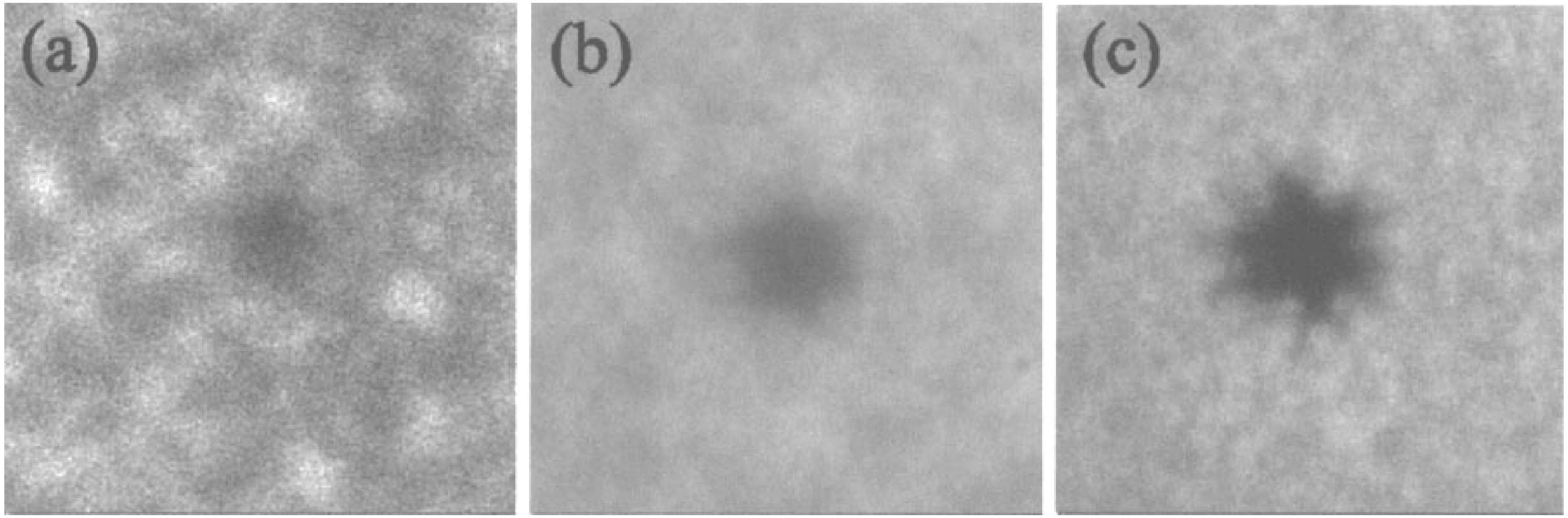
$$M = \cos\phi \cos\lambda$$

$$\tau \geq \tau_c$$ **(Critical resolved shear stress)**



Contact-induced damage in GaN epilayers

CL imaging of GaN indented below the critical pop-in load revealed no detectable reduction in the intensity of CL emission.



J. E. Bradby et al., Appl. Phys. Lett., 2002, 80, pp. 383-385.

Thank you for your attention