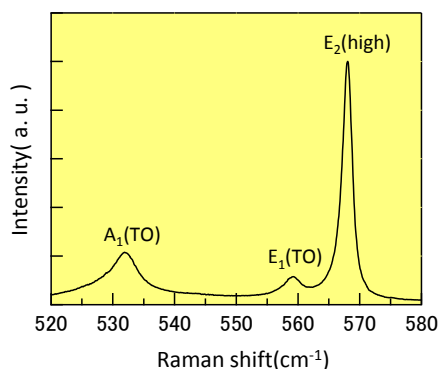


Evaluation of Temperature-dependent Stress in GaN HEMTs by Raman Spectroscopy

We evaluated the temperature-dependent stress in GaN HEMTs. The compressive stress in the GaN layer increased, as the temperature increased. The soldering process affected the stress in the GaN layer. The stress evaluation by Raman spectroscopy can be used for the optimization of packaging.

Stress evaluation of GaN by Raman Spectroscopy



Raman scattering in GaN

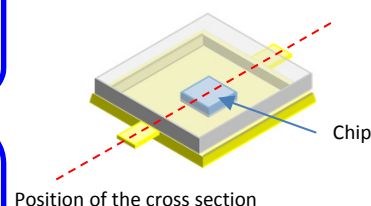
- GaN has anisotropy because of its hexagonal crystal structure.
- ⇒ Multiple Raman line can be observed. Understanding the nature of vibration modes is important.

Feature of stress analysis in TRC

- High precision measurement
Stress can be determined within \pm several MPa.
(Wavenumber precision: $\pm 0.02\text{cm}^{-1}$)
- Temperature-dependent stress measurement
A temperature of the sample can be changed from -150°C to 300°C . Stress analysis can be performed at any temperatures.

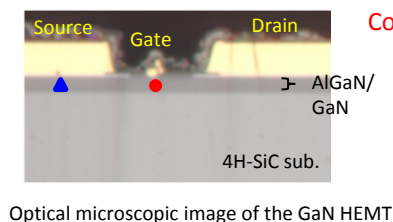
Sample

<GaN HEMT
(High Electron Mobility Transistor)>



Substrate: 4H-SiC
Temperature: -40°C , RT, 140°C
Excitation wavelength: 457.9 nm

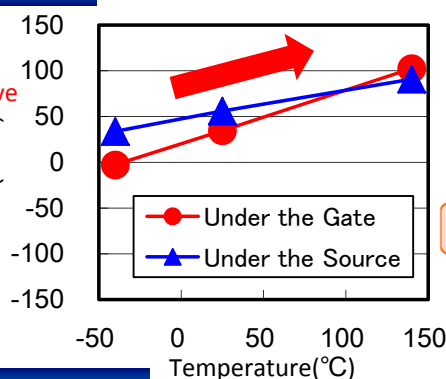
Temperature-dependent stress in GaN



Compressive

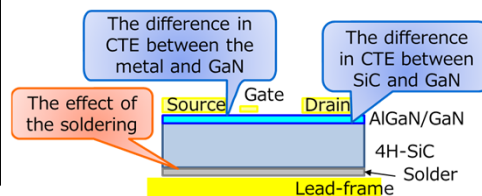
Tensile

σ (MPa)



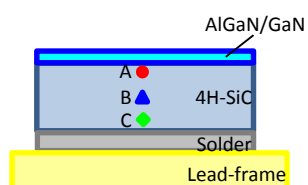
The compressive stress became large at both measurement points as the temperature increased.

What is the true cause of this temperature dependence?



CTE: Coefficient of Thermal Expansion

Temperature-dependent stress in SiC sub.

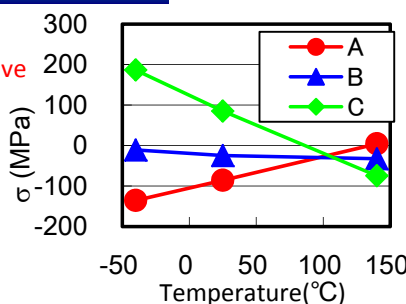


Schematic image of the GaN HEMT
(Point A is located under the gate.)

Compressive

Tensile

σ (MPa)



The temperature dependence of Point A and GaN showed the same tendency.

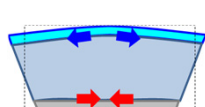
⇒ The effect of the difference in CTE between GaN and SiC is small.

The temperature dependence of the stress at Points A and B showed the reverse trend.

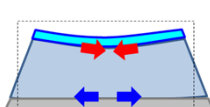
⇒ The temperature dependence of the stress at the surface was resulted from the thermal stress at the back side.

[Thermal stress in GaN layer resulted from soldering]

-40°C



140°C



The compressive stress is caused by the difference in CTE between the metal and SiC at the back side of SiC substrate.
⇒ The tensile stress is caused at the surface.

The tensile stress is caused by the difference in CTE between the metal and SiC at the back side of SiC substrate.
⇒ The compressive stress is caused at the surface.

[Summary]

- The soldering process changed the stress in the chip surface. Stress change can generate the characteristic variation and degradation.
- In addition to the matching of CTE, lowering the temperature of the soldering process can reduce the residual stress.