

## Pyroelectric Effect on Thermoelectricity of AlInN/GaN Heterostructures

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**Abstract :** Superior thermoelectric (TE) efficiency of  $\text{Al}_x\text{In}_{1-x}\text{N}$  /GaN heterostructure (HS) requires a minimum value of thermal conductivity ( $k$ ). A smaller  $k$  would lead to even further increase of TE figure of merit ( $ZT$ ). The built-in polarization (BIP) electric field of  $\text{Al}_x\text{In}_{1-x}\text{N}$  /GaN HS enhances  $S$ , and  $\sigma$  of the HS, however, the effect of BIP field on  $k$  of the HS has not been explored. Study of thermal conductivities ( $k$ : without BIP and  $k_p$ : including BIP) vs temperature predicts pyroelectric behavior of HS. Both  $k$  and  $k_p$  show crossover at a temperature  $T_p$ . The result shows that below  $T_p$ ,  $k_p < k$  due to negative thermal expansion coefficient (TEC). However, above  $T_p$ ,  $k_p > k$ . Above  $T_p$ , piezoelectric polarization dominates over spontaneous polarization due to positive TEC. This generates more lattice mismatch resulting in the significant contribution of BIP field to thermal conductivity. Thus,  $T_p$  can be considered as primary pyroelectric transition temperature of the material as above  $T_p$  thermal expansion takes place which is the reason for the secondary pyroelectric effect. It is found that below  $T_p$ ,  $k_p$  is decreased; thus enhancing TE efficiency. For  $x=0.1, 0.2$  and  $0.3$ ;  $T_p$  are close to 200, 210 and 260 K, respectively. Thus,  $k$  of the HS can be modified as per requirement by tailoring the Al composition; making it suitable simultaneously for the design of high-temperature pyroelectric sensors and TE module for maximum power production.

**Keywords :**  $\text{Al}_x\text{In}_{1-x}\text{N}$ /GaN heterostructure, built in polarization, pyroelectric behavior, thermoelectric efficiency

**Conference Title :** ICAAPMS 2019 : International Conference on Advances in Applied Physics and Materials Science

**Conference Location :** Venice, Italy

**Conference Dates :** June 20-21, 2019