Current Status and Future Prospects of High Performance Piezoelectric Single Crystals: "Lead-based" and "Lead-free"

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Crystallographically engineered Relaxor-PT single crystals, specifically PMN-PT and PZN-PT, offer much higher piezoelectric and electromechanical coupling coefficients ($d_{33} > 1{,}500$ pC/N, $k_{33} > 0.9$), when compared to PZT ceramics. Therefore, the high performance piezoelectric single crystals have been expected to replace polycrystalline PZT ceramics in many application fields such as ultrasound transducers (medical and NDA), SONAR transducer, piezoelectric actuators, piezoelectric sensors, ultrasonic motors and piezoelectric energy harvesting, etc.

Recently the solid-state single crystal growth (SSCG) technique for fabricating the high performance "lead(Pb)-based" piezoelectric single crystals such as PMN-PT and PMN-PZT has been successfully developed. Since the SSCG process is quite simple and similar to conventional sintering process, compared to conventional single crystal growth methods such as flux and Bridgman methods, it is very cost-effective and suitable to mass production. And recently the SSCG method was successfully applied to growth of "lead(Pb)-free" piezoelectric single crystals of high electromechanical coupling coefficients ($k_{33} > 0.9$).

In this presentation the recent progress on development and application of "lead-based" and "lead-free" piezoelectric single crystals will be introduced.

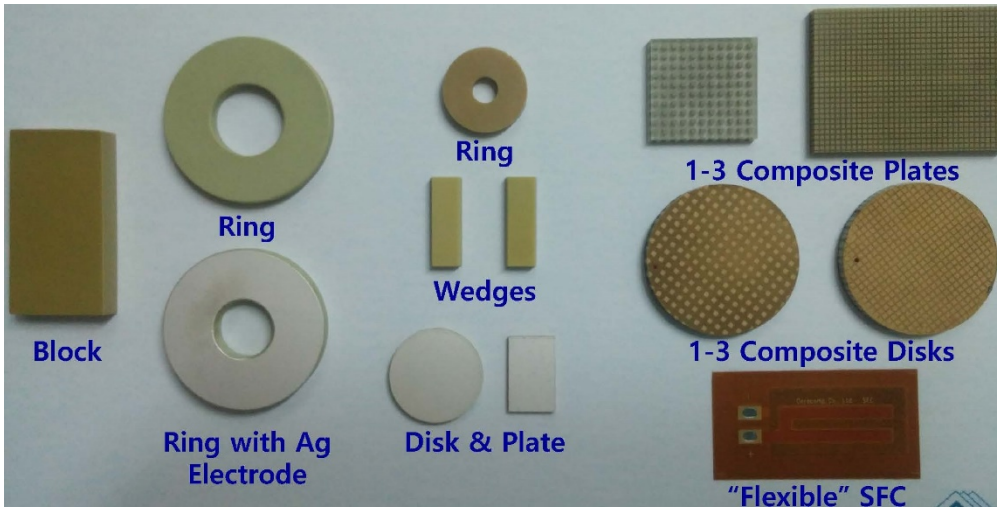

Fig. 1. Various forms of SSCG PMN-PT/PMN-PZT single crystals:
A block, rings (without/with Ag electrode), wedges, disk, plate, 1-3 single crystal-epoxy composites (plates and disks), and "flexible" single crystal fiber composite (SFC)