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High K^2 SAW device with ScAlN on Diamond

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With the advancement of wireless communication systems, wideband such as 100 MHz is required for broadband mobile communication systems at high frequency. Surface acoustic wave (SAW) devices utilizing high phase velocity poly-crystalline diamond (PCD) only has been used for narrowband devices [1]; however, combined with high K^2 material such as ScAlN, this material system might be applied to broadband devices [2,3]. In this study, Sc concentration dependence of Sc*x*Al*1-x*N /AlN /PCD SAW characteristics was investigated by fabricating one-port SAW resonator at high frequency.

First, AlN buffer layer (22nm) was deposited on PCD/Si by RF magnetron sputtering, which was followed by ScAlN deposition. Sc concentrations were controlled by changing the RF powers of Al and Sc targets. Next, Al/Cr (90nm/5nm) was deposited, and finally 3~4 GHz one-port SAW resonators with sub-micron IDTs were fabricated. Sc concentrations of four films were listed in ***Table 1*** with their thicknesses and FWHM of (0002) reflections measured by X-ray diffraction.

Table 1. Sc concentrations and thicknesses of ScAlN films with their (0002) reflection FWHM.

Sc concentration[%]	23.8	34.1	44.3	42.9
Thickness[nm]	1111	1205	718.3	746.2
FWHM[deg]	3.8	3.4	3.1	2.8

The surface morphologies of four ScAlN films with different Sc concentrations are shown in ***Fig.1***. High Sc concentration films such as 42.9% and 44.3% with smaller (0002) FWHM show better surface morphologies.

For device results, an impedance characteristic of 1port SAW resonator by Sc concentration of 42.9% is shown in ***Fig 2*** as an example. High performance characteristics of K^2 6.34% and phase velocity of 7,420m/s were obtained at 3.7 GHz. ScAlN thichness/λ dependence of phase velocity and K^2 for devices for all the devices are depicted in ***Fig.3***. Here, note that the simulated dotted lines are based on the calculation that the piezo-electric constants are 270% of AlN [4]. As can be seen in the figure, K^2 increases with increasing Sc concentration, indicating the very large variation of Sc*x*Al*1-x*N material properties by

Sc concentration. The results indicate that optimizations of Sc concentration as well as the c-axis orientation play an important role in realization of this material system in future practical use in high frequency broadband applications.

References [1] S.Shikata et al., New Diam. and Frontier Carbon Technol. 15, (2005) 349 [2] K. Hashimoto et al., Proc. IEEE Ultrason. Symp. (2012) 1926 [3] Y. Kobayashi et al., Diam. Relat. Mat., 111 (2021) 108190
[4] T.Fujii et al. IEICE 2013/6 J96–A No. 6

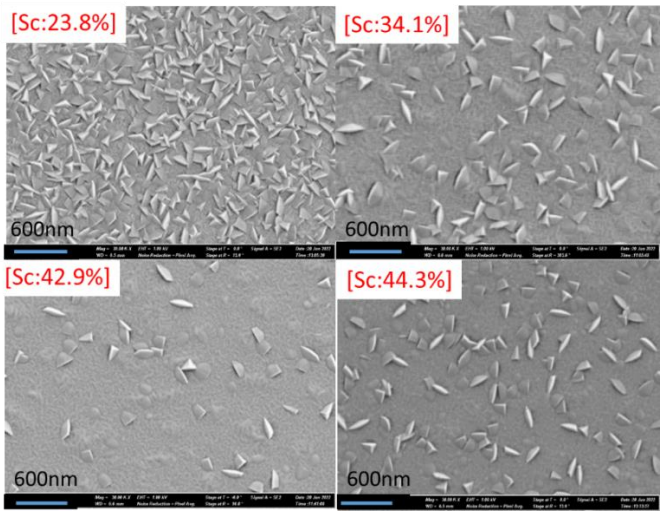
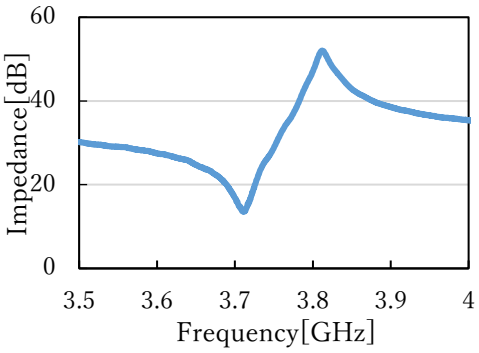


Fig1. Surface morphologies of four ScAlN films with different Sc concentrations.



Frequency[GHz]	3.71
Q	120
K2[%]	6.34
V[m/s]	7420

Fig 2. Frequency characteristics of 1port SAW resonator by Sc concentration of 42.9%.

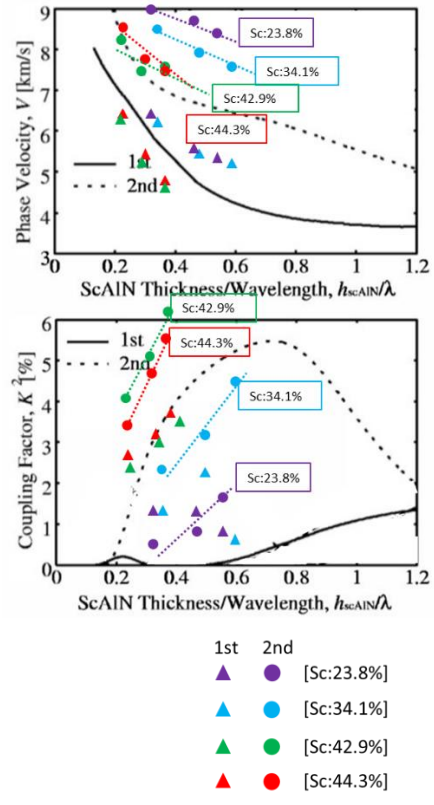


Fig 3. Sc concentration dependence of Vp and K^2.