The dry etching process for patterning P(VDF-TeFE) thin film with various conditions

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1. Introduction
We have used P(VDF-TeFE) thin film to fabricate membrane-type micro-generator in which electricity is generated by human voice vibration. Increasing the surface area of the film, the film was etched by dry etching processes as well as it will be easy to receive the vibration. In this study, dry etching conditions for P(VDF-TeFE) thin film are used and its variation is observed.

Energy harvesting technology is an advanced concept by which so many energy sources in our life can be converted into usable electrical power. Among them, we have focused on human voice energy to extend for operating portable devices. It is known that the voice is composed of acoustic waves with low frequency. For practical use of human voice as an energy sources, a processes as well as it will be easy to receive the vibration.

2. Experimental procedure
In this study, dry etching conditions for P(VDF-TeFE) thin film were used as parameter to find out the best condition. A method of dry etching for this film was not reported earlier. The dry etching conditions are shown in Table.1. To investigate etching process, the temperature and RF bias power are used as parameter to find out the best condition of etching. CF$_4$ and O$_2$ gases are used for dry etching and the gas combination is changed.

3. Results and discussion
Fig.3 shows XPS spectra of the samples formed with mixed solutions in which the ratio varies from 0 to 100 %. Broad peaks of -CF$_2$-CF$_2$-CF$_2$- and -CF$_2$-CH$_2$-CF$_2$- bonds are observed for MEK 75 % and 50 % solutions. In cases of high DMA i.e. when MEK ratio is 25 % or 0 %, an adhesion

4. Conclusion
In order to pattern P(VDF-TeFE) thin film precisely for a membrane-type micro-generator, we have carried out the dry etching process using ICP-RIE equipment. The etching of the film was affected by a ratio of O$_2$+CF$_4$ mixture gas. As a result, we understand the etching of the film is mainly progressed by the O$_2$ radical reactions. Moreover, it is thought that the etching rate at the gas ratio of 0.6 is good enough to fabricate the film.

Acknowledgements
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References
Fig. 1 Schematic of micro-generator using patterned P(VDF-TeFE) thin film as a membrane.

Fig. 2 Molecular structure of P(VDF-TeFE).

Fig. 3 XPS spectra (C1s) of P(VDF-TeFE) film for MEK ratio.

Table 1: Condition of the etching process

<table>
<thead>
<tr>
<th>CF₄ flow rate</th>
<th>0–15 sccm</th>
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<tr>
<td>O₂ flow rate</td>
<td>0–15 sccm</td>
</tr>
<tr>
<td>ICP power</td>
<td>400 W</td>
</tr>
<tr>
<td>RF bias</td>
<td>0, 100 W</td>
</tr>
<tr>
<td>Pressure</td>
<td>6 Pa</td>
</tr>
<tr>
<td>Temperature</td>
<td>RT, 0–25 °C</td>
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Fig. 5 Etching rate for changing the gas combinations.

Fig. 6 SEM image of the film which was etched with gas combination O₂/(O₂+CF₄) = 0.6.

Fig. 4 Polarization versus electric field hysteresis loop of P(VDF-TeFE) film with MEK 75% solvent.

Fig. 7 Etching rate of P(VDF-TeFE) film for changing temperature and RF bias power conditions.