Effect of Electron Irradiation on Properties of RTV560 Silicon Rubber

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Abstract: *High voltage terminals are enclosed with RTV560 silicone rubber. Space travelling wave tubes are exposed in irradiation environment. As one organic elastomer, silicone rubber is degraded by the radiation. In the paper, effect of electron irradiation on properties of RTV560 silicone rubber was investigation. The used electrons have an energy range 10~100 keV, and the irradiation fluence ranges from 1.0×10^6 rad to 1.0×10^7 rad. At last, roughness, hardness, DTA and TGA were measured and analyzed for all samples.*

Keywords: properties; electron irradiation; silicone rubber

Introduction

Normal operating voltages of space traveling wave tube (TWT) are high and deadly. In order to avoid high-pressure discharge, high voltage terminals must be enclosed with insulating material. Silicone rubber can form perfect insulation and usually is used.

Silicone rubber is one kind of organic elastomer. Space traveling wave tube is used in space. Space radiation is energetic and complex. It is composed of many different particles. The radiation hardiness of the organic materials used in TWT plays a large role in determining the useful lifetime of the TWT.

In order to improving reliability, effect of electron irradiation on properties of silicon rubber was investigated in the paper.

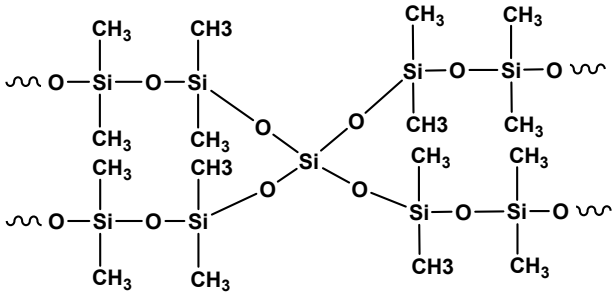

Figure1. Schematic of structure of silicone rubber

EXPERIMENTAL PROCEDURE

In the paper, RTV560 silicone rubber was used. The big samples of about 150mm diameter were prepared, and then the big ones were cut into small one of about 30mm diameter.

These used electrons have an energy range 10~100 keV. The vacuum pressure is below 10^{-3}Pa during experimental duration. The irradiation fluence ranges from 1.0×10^6 rad to 1.0×10^7rad. The as prepared samples were irradiated by electrons, and test conditions were shown in table 1.

Table 1. Test conditions of electron irradiation

Sample ID.	electron energy (keV)	irradiation fluence (cm^{-2})	Sample temperature (K)
H1-e	10	$\Phi e1=5\times10^{14}$	300
H2-e	30	$\Phi e2=1\times10^{15}$	300
H3-e	50	$\Phi e3=5\times10^{15}$	300
H4-e	70	$\Phi e4=1\times10^{16}$ $\Phi e5=5\times10^{16}$	300

Figure2. Photo of silicone rubber samples

Roughness, hardness, DTA and TGA were measured for all samples.

RESULTS AND DISCUSSION

Figure 3 shows the curve of roughness with irradiation fluence when the electrons energy is 100 keV. As irradiation fluence increases, firstly the roughness of the samples goes up, and go down when the irradiation fluence Φ is $5\times10^{15}cm^{-2}$. The increase of roughness can result from degradation of surface groups with poor chemical stability. When the irradiation fluence Φ is $5\times10^{15}cm^{-2}$, surface etch

can occur. So the surface roughness of silicone rubber goes down.

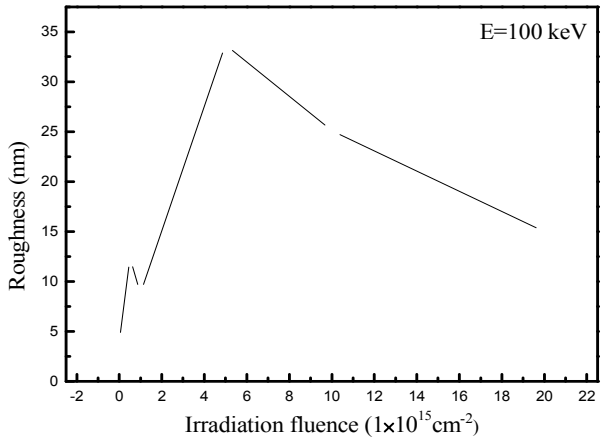

Figure3. The curve of roughness with irradiation fluence

Figure 4 shows the curve of hardness with irradiation fluence. The Shore hardness of the unirradiated samples is 71.5HA. As irradiation fluence increases, firstly the Shore hardness of the samples goes up, and go down when the irradiation fluence Φ is $5\times10^{15}cm^{-2}$. Molecular bonds were broken by electron irradiation. Free radicals were generated. Movement of the Free radicals brought about cross-linking of silicone rubber molecular chain. The increase of hardness results from cross linking. As irradiation fluence went up further, molecular bonds of silicone rubber molecular main chain were broken. The unsaturated link occurred, the intermolecular force became weak. So Shore hardness went down.

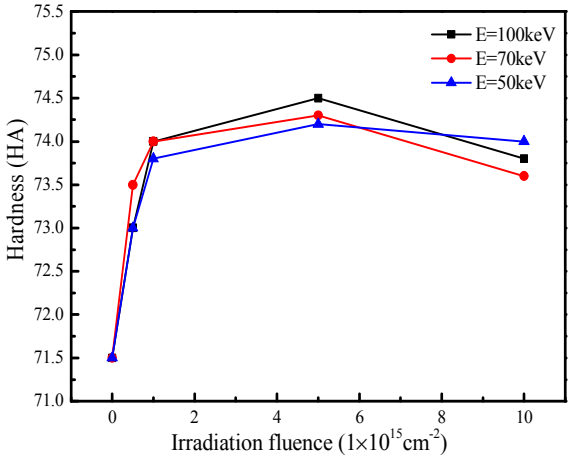

Figure4. The curves of hardness with irradiation fluence

Figure 5 and Figure 6 shows the curves of TGA and DTA with different irradiation fluence when the electrons energy is 70 keV. There was no significant alteration in thermal degradation of silicone rubber with the different irradiation fluence. As irradiation fluence increases, the peak of DTA moves left. So there was no significant alteration in thermal stability of silicone rubber with electron irradiation.

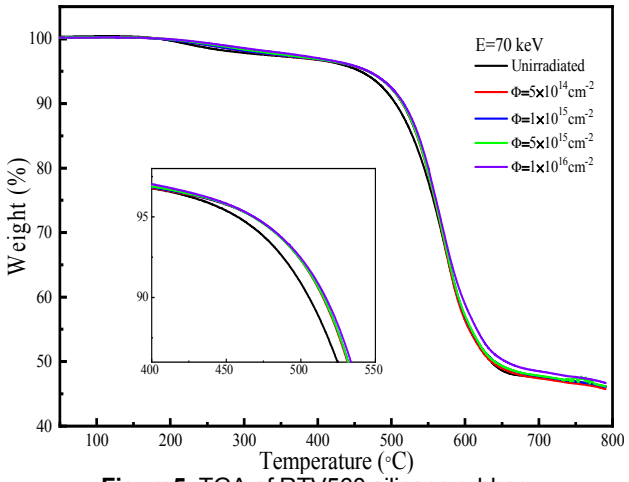

Figure5. TGA of RTV560 silicone rubber

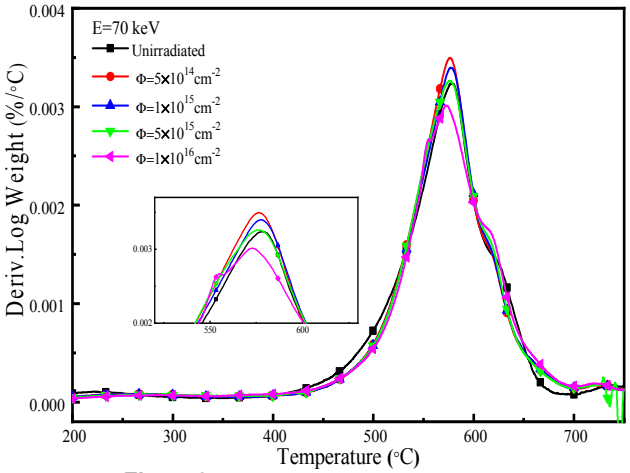

Figure6. DTA of RTV560 silicone rubber

CONCLUSION

As irradiation fluence increases, firstly the roughness of the samples goes up, and goes down. Electron irradiation brings about the increase of shore hardness. Results from TGA and DTA test shows that there was no significant alteration in thermal stability of silicone rubber with electron irradiation.

References

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