This presentation describes a study on gas evolution of plasma expansion in a reflex-triode virtual cathode oscillator (vircator) at ultra-high vacuum (UHV). Research has shown that explosive electron emission (EEE) processes at the cathode and ion/electron bombardment at the anode cause material erosion that produces regions of localized plasma. This plasma expansion has shown to lower gap impedance, cut off microwave performance and spoil low vacuum levels over time. The goal of the study is to identify the gas species and their sources to better understand and limit the negative effects of plasma expansion in sealed tubes. The vacuum tube under investigation is a triode-geometry vircator with 20 cm² cathode surface, driven by a 80 J Marx Generator with an approximate peak voltage and current, and pulse width of 200 kV and 5 kA, and 200 ns, respectively.

During the study, titanium, nickel, and stainless steel were chosen as anode materials, and aluminum and carbon-fiber for the cathodes. Surface preparation of the anodes consisted of sand blasting, vibratory and chemical bathing, electropolishing, and temperature bake-out at 300°C. Hydrogen, carbon monoxide, nitrogen and methane were the main outgassing species collected by a residual gas analyzer. With a base vacuum level of 10⁻⁹ torr, preliminary data has shown that approximately 2.5·10¹⁵ molecules are released during the pulse increasing the background pressure up to 10⁻⁵ torr. The data also suggests that reduction in outgassing by two to three orders of magnitude is achievable by extended tube baking times and exposing the electrodes to an argon / 10% oxygen microwave plasma discharge. Scanning electron microscope (SEM) imaging and energy-dispersive x-ray spectroscopy (EDAX) have shown fragments of the cathode and chemisorbed contaminants from the cathode are deposited on the anode up to 50 µm in size. To better resolve the gas evolution dynamics high-speed photography was utilized to track the plasma development. The intent of this presentation is to identify the major source and mechanism of outgassing (anode or cathode) and, the best performing anode material.