Purpose:
Titanium dioxide (TiO2) nanotubes grown by electrochemical oxidation can be used as a cold cathode X-ray source. They can potentially address some of the current limitations of carbon nanotubes. As an oxide, TiO2 is not affected by residual oxygen present in the tube, which otherwise can severely degrade the device's performance. Furthermore, TiO2 nanotubes have a good electrical contact with the conductive Ti sheet, which eliminates the heating effects. One important parameter for high performance X-ray tubes is the electron field emission current. The current density is strongly dependent on the nanotube's density due to electric field screening effects. The goal of this work was to develop a method for producing low density nanotube arrays and to investigate field emission properties.

Methods:
TiO2 nanotubes were grown via electrochemical oxidation of Ti sheets at 40 V using ethylene glycol, glycerol solvents and 2% NH4F acid. The field emission measurements were performed in a vacuum chamber with a base pressure of 6.6x10-5 Pa in a voltage range of 0-1000 V. A copper grid with 30 m diameter wire and 70% open area was used as an anode.

Results:
The samples grown in ethylene glycol + 2% NH4F revealed a clustered pattern with 1-2 μm spacing, unlike the regular pattern of dense, highly-aligned tubular structure. Clustered nanotube samples had a significant improvement in field emission performance with reduced threshold voltage (>2 times), and increased field enhancement factor (>5 times) and current density (6 times), as compared to standard nanotube samples. This improvement is thought to be due to the reduction in electric field screening effects.

Conclusions:
Our results show the significant enhancement in field emission performance of clustered TiO2 nanotube arrays when compared to the standard highly-aligned nanotubes. This implies possibility for further increase the X-ray flux from the emission source.