Nanoparticles that form in peeling Scotch Tape produce X-rays

X-rays are shown produced as the electrons that form from the EM radiation emitted from nanoparticles upon electrical breakdown reach high velocities and by collsion undergo bremsstrahlung.

Jan. 27, 2009 - *PRLog* **-- Background** The x-rays produced in the peeling of Scotch Tape find origin in the field of tribology where photons and electrons are produced by fracturing or rubbing materials. Tribology has a long history beginning over 2000 years ago when the Greeks discovered static electricity upon rubbing an amber rod with a cloth. But the electrons formed in tribology must be accelerated to higher energies to produce x-rays.

In this regard, x-rays were discovered by Röntgen in 1895 while experimenting with the cathode ray tube (CRT). CRTs are devices which the positive anode attracts electrons from the negative cathode, the process occurring in a vacuum. The electrons upon collision with the anode emit x-rays upon deceleration called bremsstrahlung.

Nevertheless, x-rays have been observed in tribology. In 1930, x-rays were reported by Obreimoff upon splitting of mica by a wedge in an evacuated glass vessel under 1 – 0.1 mm mercury vacuum, the emission found similar to a Geissler tube.

In 2008, x-rays were reported at UCLA by Camara, et al. by peeling 3M brand Scotch tape at steady 3 cm/s in a vacuum. The tape did not emit x-rays continuously, but in short nanosecond bursts – accumulating enough energy to produce an x-ray image of a finger in a second. Most brands of clear adhesive tape also give off x-rays, albeit with a different spectrum of energies, although duct tape did not.

But how are x-rays produced in splitting mica or peeling tape?

X-ray Mechanisms in Tribology

Split mica and peeled tape are similar to the CRT in that a gap momentarily forms between the surfaces, so if one surface is charged positive and the other negative, electrons may be accelerated to high velocities. Provided the accumulated charge produces a high voltage across the gap, both split mica and peeled tape act as a CRT in producing x-rays.

The problem is Röntgen charged the CRT with external voltage while the mica and tape must somehow be charged in the process by which they are formed.

In peeling tape, the charging in peeling tape is commonly thought to occur by the abrupt separation of the sticky acrylic adhesive from the polyethylene (PE) backing, the adhesive charged positive with the PE negative charged. However, this is unlikely. For if it was, steady x-rays would be emitted and not the in nanosecond bursts as observed.

Instead, the charging accumulates non-uniformly from EM radiation induced from NPs that form as adhesive fractures. In fact, UCLA showed x-ray emission correlates with the collapse of the stick-slip peeling force. Many local discharges therefore occur that are not uniform over the full separation. Contrary to long-standing thought that tribocharging occurs over the full separation with positive charges on one and the opposite charge on the other is highly unlikely making Harvey's statement still applicable.

"It is not possible to prove that mica sheets …or Scotch tape are oppositely charged as a whole when

pulled apart."

Another tribocharging mechanism producing non-uniform charge distribution is suggested.

X-rays from Nanoparticles in Peeling Tape

Accumulated tribocharging in peeling tape by EM emission from nanoparticles is proposed because of the non-uniform nanosecond x-ray bursts observed in peeling Scotch tape. See www.nanoqed.net

Prior to peeling, atoms in the adhesive are not under EM confinement and have full thermal kT energy. Here, k is Boltzmann's constant and T is absolute temperature. But upon peeling, the atoms in nanoparticles that form in the gap between adhesive and PE are under EM confinement at vacuum ultraviolet (VUV) frequencies that by quantum mechanics are restricted to vanishing kT energy. Momentarily, the nanoparticle atoms therefore have kT energy in excess of that allowed by quantum mechanics that must somehow be conserved.

Usually, EM energy is conserved by an increase in temperatue. But the specific heat of nanoparticles at VUV frequencies also vanishes, and therefore the excess kT energy must be conserved in another way. Since the nanoparticles have EM confinement frequencies at VUV levels, and since the lowest frequency allowed in the nanoparticle is its EM frequency, the low frequency kT energy is frequency up-converted to VUV levels by quantum electrodynamics.

Conservation then proceeds by a burst of VUV radiation that by the photoelectric effect charges the adhesive positive while the liberated electrons charge the PE negative. Charge accumulates non-uniformly during peeling by the VUV radiation from a continual supply of nanoparticles until the breakdown of voltage is reached across the gap between the adhesive and the PE. Electrons from the PE then are accelerated to velocities of about 108 m/s in gaps up to 1000 microns. Upon collision with the adhesive, electron bremstraahlung produces x-rays from 15 to 100 keV.

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About QED induced EM radiation: Classically, thermal EM radiation conserves heat by an increase in temperature. But at the nanoscale, temperature increases are forbidden by quantum mechanics. QED radiation explains how heat is conserved by the emission of nonthermal EM radiation.

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Source	Thomas Prevenslik
City/Town	Youngwood
State/Province	Pennsylvania
Zip	15697
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