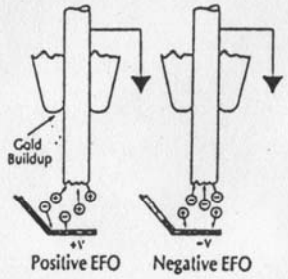
Positive Results from a Negative EFO

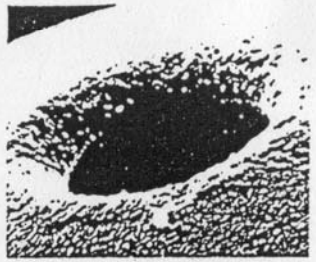
Electronic Flame Off (EFO) refers to the current technique used to form the ball in gold wire ball bonding. With most modern EFO systems, the size of the ball and its shape are formed by melting the tail of the gold wire in a glow discharge. Recently, however, it has become apparent that the EFO spark is contributing to shortened tool life, clogging of ceramic capillaries, and can even cause damage to the face of the capillary.

In a conventional EFO unit, the wire is held at electrical ground, while a positive voltage is applied to the EFO wand. Since the wire is electrically negative, relative to the wand, positively charged gas ions are formed in the discharge. These ions are accelerated toward the wire. They pass through the cathode fall region immediately surrounding the wire, acquiring several hundred electron-volts of energy in the process. Finally they reach the wire, where they impact, heating the wire to its melting point. The ball forms due to surface tension in the molten wire.

The positive ions, however, also sputter gold as they strike the wire. The sputtered gold lands on the capillary tip and eventually clogs the bore, reducing capillary life.

K&S engineers developed a solution to this problem: reverse the discharge polarity, making the wire positive with respect to the wand. Now the positive ions formed in the discharge are attracted to the wand, while electrons and negative ions are driven toward the wire. These electrons and negative ions are accelerated through the anode fall region, finally striking the wire. Since the anode fall has a much smaller potential drop than the cathode fall (tens of volts rather than hundreds), these electrons and ions acquire only a small fraction of the energy imparted to ions near the cathode. Sputtering doesn't occur at the wire under these conditions, capillary clogging is greatly reduced, and capillary life is greatly extended as a result. Note that higher discharge currents are needed for ball formation with a negative wand.





Gold build-up, resulting from the "sputter" action of a positively biased EFO, may be seen on this SEM photo of a ceramic capillary's tip, magnified 120 times.

An added benefit of the negative-EFO technology enables precise ball size control. A duration-of-pulse control regulates a continuous EFO power level that can accurately produce smaller ball sizes than conventional EFO systems. This advantage alone would justify the change for many applications, since it allows about a 33% reduction in the ball-to-wire-diameter ratio. Besides the obvious advantages in small bond pad applications, this capacity means fewer bond placement errors on larger pads and, of course, less re-work.