## **Assessment of Current Density Singularity in Electromigration of Solder Bumps**

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## Abstract

This paper investigates the current density singularity in electromigration of solder bumps. A theoretical analysis is performed on a homogenous wedge with arbitrary apex angle, 2( ), when the current flow passes through. A potential difference is applied at a distance far away from the tip of the wedge. It is found that current density singularity exists at the tip of the wedges when the angles ". The acute angles represent the corner configuration of the actual solder bump and the interconnect. The current crowding in bumps is a

		of the material faces of wedge		oundary condit	ions
` ,	at	for all r	,		(5)
Substitu	ting the BC,	in the	Equation	(4) leads to	(-)
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Since <sup>-</sup>	, at	we	have		
Fron	n the governi	ng equation of	electrost	atics, we have	) 
where	·	— —— , s	ubstitutin	g the assumed	l
		the Equation uation with co		et a homogene afficients as	⊛us 
The equation		, obtained ¥a	by solvir	ng the above	
Equation and produce	n (7) to the v , to th s a system n constants.	vedge faces was general for of two sime. These equation	which are a m of nultaneous ons can bo	in Equation s equations e represented	(10) with
-¥a	OS		,,		
Since E	equation (11	) is homoge nust be equa		e determinan in order to	
and, the	roots of this	equation are	obtained a	as follows,	
	m3 y	₫ ® .			
	e general so			tage function, ith arbitrary a	

In Equations (18) and (19) the exponential of r is negative for both the angles. When r approaches zero, — approaches infinity. Subsequently current density also equals to infinity.

## Figure 7 Three different mesh schemes

To remove the singularity effect, one method is to extract the averaged current density over certain volumes. In this method the current density is averaged over all the elements of the selected volumes as following:

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where, is average current density, is current density in each element, is volume of each element. Two different volume averaging approaches are studied. In the first

mesh sizes are tabulated in Table 1. As the mesh size is reduced by a factor of four, the maximum current density has increased by 24%. The average current densities calculated in the bottom disk for all the mesh schemes are the same. It is observed that the averaging has decreased the current density value in bottom disk by 56% compared to the maximum current density (in the case of 'X/4' mesh size).

Figure 12 Current density contours with different meshes in the bottom disk

Table 1 The Maximum and Average Current Densities Calculated in Bottom Disk for Different Mesh Sizes

Mesh Size	Max.	Average
	Current dens.	Current dens.
	(Bottom Disk	in Bottom
	& Crescent)	Disk
	$(A/m^2)$	(A/m <sup>2</sup> )
Х	0.55e8	0.30e8
x/2	0.60e8	0.30e8
x/4	0.69e8	0.30e8

Table 2 summarizes all the averaged current density values calculated for all thicknesses (p/r = 0.2, 0.4 and 0.6) of crescents with differen