C e E e TEC Te g

1 1 2

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2

Abstract

( ) ( ) ( ) ( ) ( ) , ( ) ( ) (τ) τ

τ τ τ

Introduction

, ( ),) three $\alpha^2\sigma/\kappa$ (α κ ρ) α ( ) three

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) (τ) (
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Detachment of Metal Junctions from Ceramics

n N τ

$$\tau \quad \frac{\tau_{nom}}{(1-\frac{n}{N})} \qquad (\;)$$

N

( )

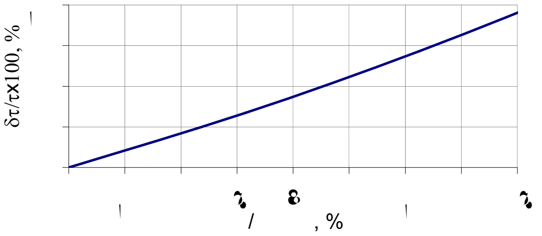

Figure 1: *Time constant dependence on the relative ratio of the metal junctions detached from the ceramic substrate.*

n N

Confused p-n pellets polarity

n

$$Z = Z_{nom}\left(1-\frac{n}{N}\right)^2 \qquad (\;)$$

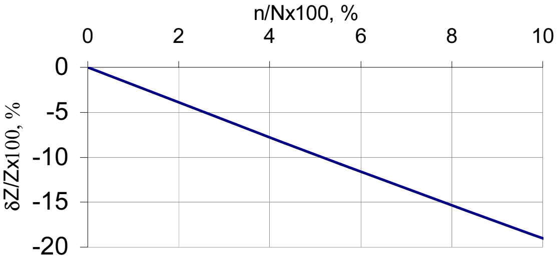

Figure 2: *Figure-of-Merit dependence on the relative ratio of the confused pellets.*

τ

n N

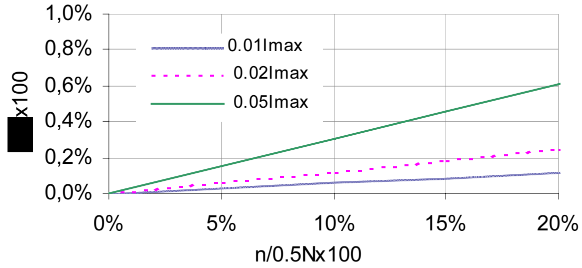

Figure 3: *Time constant dependence on the relative number of confused pellets at different current values*

τ

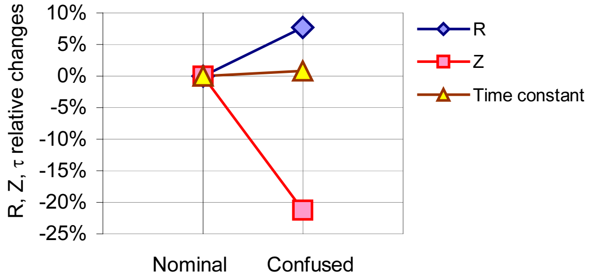

Figure 4: *Experimental data on average relative changes of R, Z, τ for TECs with confused pellets polarity (Lot 1)*

Table 1. *Measured Z, R, τ relative changes (Lot 1)*

δR/R	δZ/Z	δτ/τ
%	%	%

( )

%

Table 2. *Experiment and theory comparison (Lot 2)*

n/Nx100	$\delta Z/Z_{exp}$	$\delta Z/Z_{calc}$
%	%	%
%	%	%
%	%	%

Thermal and Electric Contact of Pellet Wall and Solder Meniscus

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Table 3. *Solder and TE material properties comparison*

Material	Electrical Conductivity, $Ohm^{-1}\cdot cm^{-1}$	Thermal Conductivity, W/m·K
	3	
( )	4	

Pellet wall

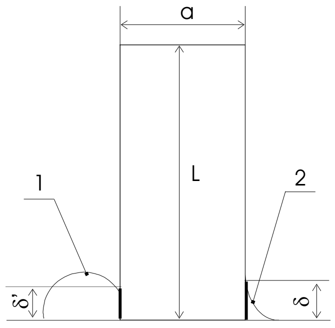

Figure 5: *Non-wetting (1) and wetting (2) solder menisci rough model*

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δ' *L* *a* τ

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$$Z,\tau=\frac{Z_{nom},\tau_{nom}}{1+\frac{4\delta'^2}{a(L-\delta')}},\ R=const$$

( )

L ( )

)

δ

$$R,\tau=\frac{R_{nom},\tau_{nom}}{1+\frac{4\delta^2}{a(L-\delta)}},\ Z=const$$

( )

τ

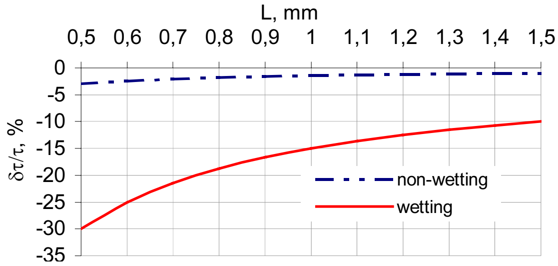

Figure 6: *Time constant change vs pellet height at non-wetting (δ' =0.045mm) and wetting (δ =0.15mm); a=0.6mm.*

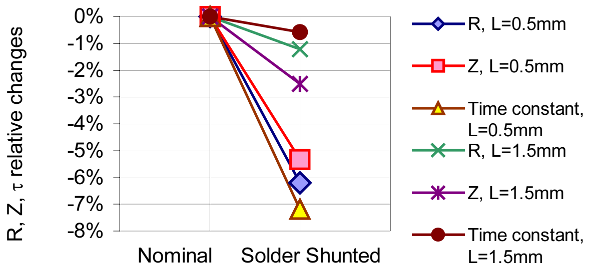

Figure 7: *Experimental data on average relative changes of R, Z, τ for TECs with pellets walls solder-wetted*

Table 4. *Numerical data and theoretical results (Fig. 7).*

L, mm	a, mm	Experiment			Theory X:Z,R,τ
		δR/R	δZ/Z	δτ/τ	δX/X, δ=0.08mm
		%	%	%	%
		%	%	%	%

( ) ( )

δ

( )

TEC Pellets Short Circuit

n

n/N

$$R,Z=(1-\frac{n}{N})R_{nom},Z_{nom}$$ ( )

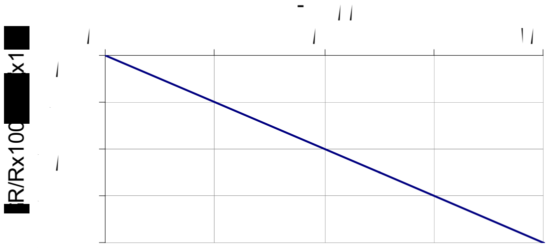

Figure 8: *Calculated R and Z behavior for TECs with n short circuit pellets*

τ

$$\tau \quad \frac{\tau_{nom}}{(1+\frac{n}{N})}$$ ( )

%

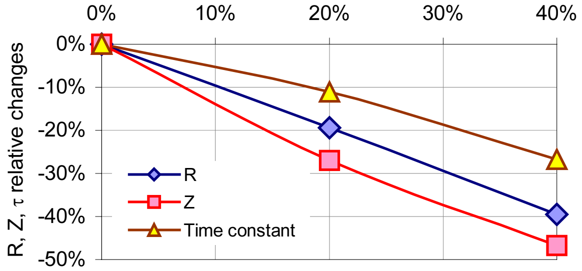

Figure 8: *Experimental data on average relative changes of R, Z, τ for TECs with short-circuited pellets*

Table 5. *Experimental / calculated data for Fig. 8 case.*

n/N	Experiment			Theory		
	δR/R	δZ/Z	δτ/τ	δR/R	δZ/Z	δτ/τ
%	%	%	%	%	%	%
%	%	%	%	%	%	%

Two-stage TEC: Confused Stage Polarity

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τ

τ

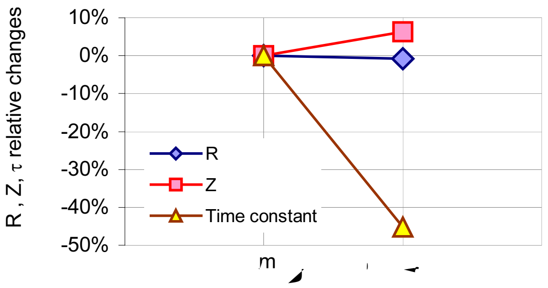

Figure 9: *Experimental data on average relative changes of R, Z, τ for 2-tage TECs correct and inverted*

Material Degradation