Smart Material Chapter 4 Solutions

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[1]:
```
# toc
import sympy as sp
import numpy as np
import matplotlib.pyplot as plt

plt.style.use('maroon_ipynb.mplstyle')
```

Contents

Problem 4.1

Compute the stress required to produce 100 microstrain in APC 856 when the applied electric field is held constant at zero Compute the stress required to produce 100 microstrain when the electric displacement is held equal to zero.

Property	Unit	Symbol	APC 856	PZT-5H	PVDF
Relative dielectric constant	unitless	ε_r	4100	3800	12–13
Curie temperature	°C	T_c	150	250	
Coupling coefficient	unitless	k_{33}	0.73	0.75	
		k_{31}	0.36		0.12
		k_{15}	0.65		
Strain coefficient	10^{-12} C/N or m/V	d_{33}	620	650	−33
		$-d_{31}$	260	320	−23
		d_{15}	710		
Elastic compliance	10^{-12} m^2/N	s_{11}^E	15	16.1	250–500
		s_{33}^E	17	20	
Density	g/cm^3	ρ	7.5	7.8	1.78

Solution

We can use the constitutive equations.

$$S = sT + dE$$

$$D = dT + \epsilon E$$

[2]:
```
S = 100e-6
s = 17e-12  # m^2/N
T = S/s
T  # Pa
```

[2]:
```
5882352.941176471
```

For finding the open circuit stress, we need the open circuit compliance.

$$s^D = s^E(1 - k^2)$$

[3]:
```
SD = s*(1 - 0.73**2)
T = S/SD
T  # Pa
```

[3]:
```
12593348.193484202
```