

PN-2 Electromechanical characteristics matrix

Stiffness coefficient matrix

$$\begin{bmatrix} C_{11}^E & C_{12}^E & C_{13}^E & 0 & 0 & 0 \\ C_{12}^E & C_{11}^E & C_{13}^E & 0 & 0 & 0 \\ C_{13}^E & C_{13}^E & C_{33}^E & 0 & 0 & 0 \\ 0 & 0 & 0 & C_{44}^E & 0 & 0 \\ 0 & 0 & 0 & 0 & C_{55}^E & 0 \\ 0 & 0 & 0 & 0 & 0 & C_{66}^E \end{bmatrix} = \begin{bmatrix} 5 & 1.6 & 2.2 & 0 & 0 & 0 \\ 1.6 & 5 & 2.2 & 0 & 0 & 0 \\ 2.2 & 2.2 & 6.8 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2.3 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2.3 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1.7 \end{bmatrix}^E \quad 10^{10} N/m^2$$

$$\begin{bmatrix} C_{11}^D & C_{12}^D & C_{13}^D & 0 & 0 & 0 \\ C_{12}^D & C_{11}^D & C_{13}^D & 0 & 0 & 0 \\ C_{13}^D & C_{13}^D & C_{33}^D & 0 & 0 & 0 \\ 0 & 0 & 0 & C_{44}^D & 0 & 0 \\ 0 & 0 & 0 & 0 & C_{55}^D & 0 \\ 0 & 0 & 0 & 0 & 0 & C_{66}^D \end{bmatrix} = \begin{bmatrix} 5 & 1.7 & 2.3 & 0 & 0 & 0 \\ 1.7 & 5 & 2.3 & 0 & 0 & 0 \\ 2.3 & 2.3 & 7.7 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2.4 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2.4 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1.7 \end{bmatrix}^D \quad 10^{10} N/m^2$$

Elastic Flexibility Coefficient Matrix

$$\begin{bmatrix} S_{11}^E & S_{12}^E & S_{13}^E & 0 & 0 & 0 \\ S_{12}^E & S_{11}^E & S_{13}^E & 0 & 0 & 0 \\ S_{13}^E & S_{13}^E & S_{33}^E & 0 & 0 & 0 \\ 0 & 0 & 0 & S_{44}^E & 0 & 0 \\ 0 & 0 & 0 & 0 & S_{55}^E & 0 \\ 0 & 0 & 0 & 0 & 0 & S_{66}^E \end{bmatrix} = \begin{bmatrix} 24.4 & -5.4 & -6.1 & 0 & 0 & 0 \\ -5.4 & 24.4 & -6.1 & 0 & 0 & 0 \\ -6.1 & -6.1 & 18.7 & 0 & 0 & 0 \\ 0 & 0 & 0 & 43.1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 43.1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 59.6 \end{bmatrix}^E \quad 10^{-12} m^2/N$$

$$\begin{bmatrix} S_{11}^D & S_{12}^D & S_{13}^D & 0 & 0 & 0 \\ S_{12}^D & S_{11}^D & S_{13}^D & 0 & 0 & 0 \\ S_{13}^D & S_{13}^D & S_{33}^D & 0 & 0 & 0 \\ 0 & 0 & 0 & S_{44}^D & 0 & 0 \\ 0 & 0 & 0 & 0 & S_{55}^D & 0 \\ 0 & 0 & 0 & 0 & 0 & S_{66}^D \end{bmatrix} = \begin{bmatrix} 24.3 & -5.5 & -5.6 & 0 & 0 & 0 \\ -5.5 & 24.3 & -5.6 & 0 & 0 & 0 \\ -5.6 & -5.6 & 16.1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 41 & 0 & 0 \\ 0 & 0 & 0 & 0 & 41 & 0 \\ 0 & 0 & 0 & 0 & 0 & 59.6 \end{bmatrix}^D \quad 10^{-12} m^2/N$$

Piezoelectric constant matrix

$$\begin{bmatrix} 0 & 0 & 0 & 0 & d_{15} & 0 \\ 0 & 0 & 0 & d_{24} & 0 & 0 \\ d_{31} & d_{31} & d_{33} & 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 79 & 0 \\ 0 & 0 & 0 & 79 & 0 & 0 \\ -20 & -20 & 93 & 0 & 0 & 0 \end{bmatrix} \quad 10^{12} \text{C/N}$$

$$\begin{bmatrix} 0 & 0 & 0 & 0 & g_{15} & 0 \\ 0 & 0 & 0 & g_{24} & 0 & 0 \\ g_{31} & g_{31} & g_{33} & 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 26.3 & 0 \\ 0 & 0 & 0 & 26.3 & 0 & 0 \\ -5.9 & -5.9 & 27.8 & 0 & 0 & 0 \end{bmatrix} \quad 10^{-3} \text{Vm/N}$$

$$\begin{bmatrix} 0 & 0 & 0 & 0 & e_{15} & 0 \\ 0 & 0 & 0 & e_{24} & 0 & 0 \\ e_{31} & e_{31} & e_{33} & 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 1.8 & 0 \\ 0 & 0 & 0 & 1.8 & 0 & 0 \\ 0.7 & 0.7 & 5.4 & 0 & 0 & 0 \end{bmatrix} \quad \text{C/m}^2$$

$$\begin{bmatrix} 0 & 0 & 0 & 0 & h_{15} & 0 \\ 0 & 0 & 0 & h_{24} & 0 & 0 \\ h_{31} & h_{31} & h_{33} & 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 6.4 & 0 \\ 0 & 0 & 0 & 6.4 & 0 & 0 \\ 2.5 & 2.5 & 18.9 & 0 & 0 & 0 \end{bmatrix} \quad 10^8 \text{V/m}$$

Clamped dielectric constant Matrix

$$\begin{bmatrix} \epsilon_{11}^S/\epsilon_0 & 0 & 0 \\ 0 & \epsilon_{11}^S/\epsilon_0 & 0 \\ 0 & 0 & \epsilon_{33}^S/\epsilon_0 \end{bmatrix} = \begin{bmatrix} 320 & 0 & 0 \\ 0 & 320 & 0 \\ 0 & 0 & 320 \end{bmatrix}^S$$

Free dielectric constant matrix

$$\begin{bmatrix} \epsilon_{11}^T/\epsilon_0 & 0 & 0 \\ 0 & \epsilon_{11}^T/\epsilon_0 & 0 \\ 0 & 0 & \epsilon_{33}^T/\epsilon_0 \end{bmatrix} = \begin{bmatrix} 340 & 0 & 0 \\ 0 & 340 & 0 \\ 0 & 0 & 370 \end{bmatrix}^T$$

