Example 6.2 Calculate the threshold voltage of a silicon nMOS capacitor with a substrate doping $N_a = 10^{17}$ cm^{-3}, a 20 nm thick oxide ($\varepsilon_{ox} = 3.9\ \varepsilon_0$) and an aluminum gate ($\Phi_M = 4.1$ V), a p^+ polysilicon gate and an n^+ polysilicon gate. Use the polysilicon gate parameters listed in Example 6.1. Repeat for a pMOS capacitor with the same doping and oxide thickness. Assume there is no fixed charge in the oxide or at the oxide-silicon interface.

Solution The threshold voltage equals:

$$V_T = V_{FB} + 2\phi_F + \frac{\sqrt{4\varepsilon_s q N_a \phi_F}}{C_{ox}}$$

$$= -0.93 + 2 \times 0.42 + \frac{\sqrt{4 \times 11.9 \times 8.85 \times 10^{-14} \times 1.6 \times 10^{-19} \times 10^{17} \times 0.42}}{3.9 \times 8.85 \times 10^{-14} / 20 \times 10^{-7}}$$

$$= 0.88 \text{ V}$$

Where the flatband voltage was already calculated in example 6.1. The threshold voltage voltages for nMOS and pMOS capacitors with an aluminum or a poly-silicon gate are listed in the table below.

	Aluminum	p^+ poly	n^+ poly
nMOS	0.88 V	1.95 V	0.83 V
pMOS	-1.90 V	-0.83 V	-1.95 V