

**Example 6.2** Calculate the threshold voltage of a silicon nMOS capacitor with a substrate doping  $N_a = 10^{17} \text{ cm}^{-3}$ , a 20 nm thick oxide ( $\epsilon_{ox} = 3.9 \epsilon_0$ ) and an aluminum gate ( $\Phi_M = 4.1 \text{ V}$ ), 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:

$$\begin{aligned}
 V_T &= V_{FB} + 2\phi_F + \frac{\sqrt{4\epsilon_s q N_a \phi_F}}{C_{ox}} \\
 &= -0.93 + 2 \times 0.42 \\
 &\quad + \frac{\sqrt{4 \times 11.9 \times 8.85 \times 10^{-14} \times 1.6 \times 10^{-19} \times 10^{17} \times 0.42}}{3.9 \times 8.85 \times 10^{-14} / 20 \times 10^{-7}} \\
 &= 0.88 \text{ V}
 \end{aligned}$$

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