## 3.1.2 Drift Current

Let us next turn to the task of developing an analytical expression for the current flowing within a semiconductor as a result of carrier drift. By definition

$I$ (current) = the charge per unit time crossing an arbitrarily chosen plane of observation oriented normal to the direction of current flow.

Considering the $p$-type semiconductor bar of cross-sectional area $A$ shown in Fig. 3.3, and specifically noting the arbitrarily chosen $\boldsymbol{v}_d$-normal plane lying within the bar, we can argue:

| | | |
|---|---|---|
| $v_d t$ | ... | All holes this distance back from the $\boldsymbol{v}_d$-normal plane will cross the plane in a time $t$; |
| $v_d tA$ | ... | All holes in this volume will cross the plane in a time $t$; |
| $p v_d tA$ | ... | Holes crossing the plane in a time $t$; |
| $qp v_d tA$ | ... | Charge crossing the plane in a time $t$; |
| $qp v_d A$ | ... | Charge crossing the plane per unit time. |

The word definition of the last quantity is clearly identical to the formal definition of current. Thus

$$I_{P|drift} = qp v_d A \qquad \text{hole drift current} \tag{3.1}$$

As a practical matter, the cross-sectional area $A$ appearing in Eq. (3.1) and other current formulas is often excess baggage. Current, moreover, is generally thought of as a scalar quantity, while in reality it is obviously a vector. These deficiencies are overcome by introducing a related parameter known as the current density, **J**. **J** has the same orientation as the direction of current flow and is equal in magnitude to the current per unit area (or $J = I/A$). By inspection, the current density associated with hole drift is simply,

$$\mathbf{J}_{P|drift} = qp\boldsymbol{v}_d \tag{3.2}$$

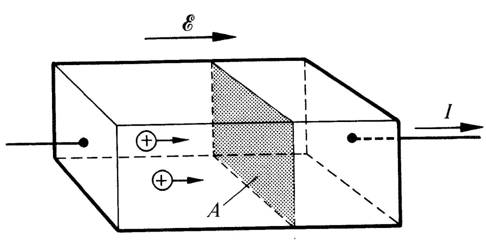


**Fig. 3.3** Expanded view of a biased $p$-type semiconductor bar of cross-sectional area $A$.