area available for deposition (deposition-function) has to be determined at the position of the substrate, in dependence of possible deposition parameters. These are mainly plasma power per unit area, bias voltage, process gas flow and in reactive sputtering: reactive gas flow. For the determination of the amount of waste (unusable deposits inside the chamber), the mass flow per unit area from the target (sputter-function) has to be determined. Once these relations are established it is possible to calculate the process times, input and output data for the deposition.

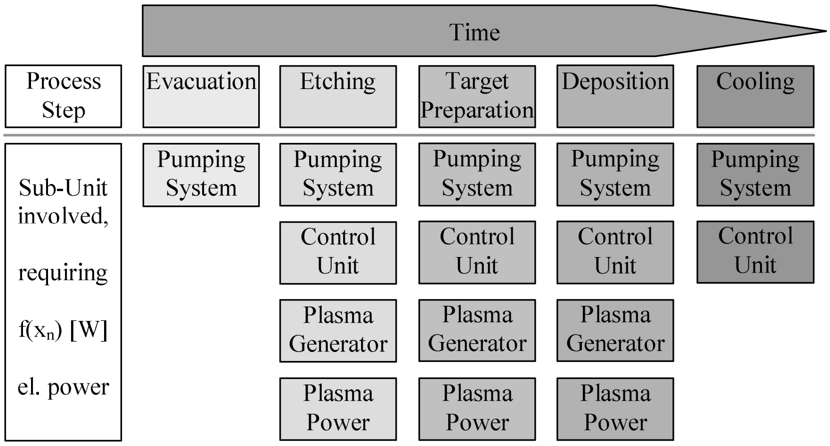

Fig. 3.28. Schematic representation of the deposition step of magnetron sputtering for the determination of the energy consumption.

Knowing the relations mentioned above it is possible to model the coating of planar work-pieces and 3-dimensional work-pieces. For 3-dimensional work-pieces however, several requirements have to be fulfilled. They have to be fairly close to rotational symmetry and they have to be rotated in front of the target only around that rotational axis. These requirements ensure that batch sizes can be easily calculated from the projected area of the work-piece.

In reality, the packing within the batch and the motion of the substrates have to receive special consideration. In mass production, for example the coating of cutting tools like drill bits, substrates are placed on holders that turn around several axes as shown in Fig. 3.29. This is done to ensure an even coating thickness and to increase the utilization of sputtered material. In this case, it is not possible to calculate the inventory data from the parameters of the work-piece and the coating. Instead, for a given coating and substrate set, the fraction of the deposited mass from the sputtered mass has to be determined. Then the inventory data can be estimated as a function of the sputtered mass instead of calculating the data directly from sputter function and deposition function.

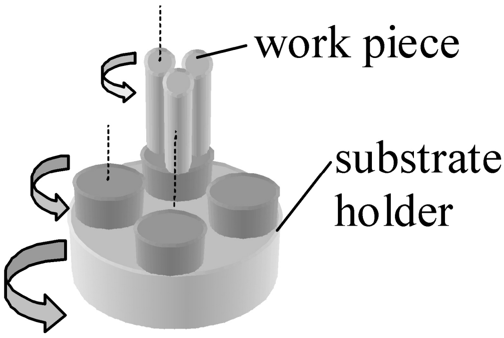

Fig. 3.29. Substrate holder with substrates rotating around multiple axes

To summarize, changing the deposition parameters of a given equipment-substrate-coating set will change the properties of the coating. Plasma power increases will increase the coating speed according to formula 3.44. Increased coating speed reduces the overall energy consumption of the coating process, because pumping and auxiliary processes need to run for shorter times. However, increasing the coating speed means higher productivity and therefore it can be said: Making the coating process more economical is beneficial for the environment.

3.2.5 Injection Moulding of Plastics

Many parts of today's consumer goods and capital goods are made from polymeric materials in a moulding process called injection moulding. Polymers are divided into thermoplastics, elastomers or thermoset materials. Each of them can be injection moulded using a variation of the basic process. Both fundamental injection moulding processes, first that for thermoplastics and second injection moulding of elastomers and thermoset materials, are covered in this chapter. However, most widespread is the injection moulding of thermoplastics.

Injection moulding is typically used for large numbers of pieces. Fig. 3.30 shows a diagram for a typical injection moulding cycle for thermoplastics.

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