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Technical Briefs

Determination of Accommodation Coefficients for N_2 at Disk-Drive Air-Bearing Surfaces

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Thermal and tangential momentum accommodation coefficients have been obtained for N_2 colliding with various surfaces of relevance to the disk-drive air bearing using molecular beam scattering techniques. Analysis of the velocity and angular distributions of scattered species indicates that N_2 is essentially fully accommodated at the relevant surfaces for energies characteristic of room temperature gas.

In a Winchester-type disk drive, the read/write head is attached to a slider that flies above a spinning disk. Optimization of drive performance and efficient fabrication requires a detailed understanding of slider flight. Traditionally, the disk-drive air-bearing has been modeled using modified Reynolds equations (Burgdorfer, 1959, Fukul and Kaneko, 1988), which requires the gas-surface accommodation coefficient as input. Particle-based methods, such as molecular dynamics or Monte Carlo simulations, have also been used to model the air flow beneath the slider directly (Alexander et al., 1994). Such simulations require more detailed knowledge of the dynamics of the gas-surface collisions. Irrespective of the method, it is clear that the modeling of the air bearing for low fly heights can benefit from detailed studies of the dynamics of the relevant gas-surface interactions.

This technical brief describes a study in which molecular beam techniques have been employed to probe experimentally the scattering of N_2 from a number of surfaces found on sliders and disks. The test surfaces included bare and lubricated slider material, slider with a sputtered carbon overcoat and a lubricated Pt(111) surface, as well as sections of a glass disk used in fly-height testing and of an actual 3.5-in disk. In each case, the lubricant molecule was a commercial perfluoro polyether with alcohol termination groups, Fomblin z-dol, with an average molecular weight of 200. In the remainder of this paper, this species will be referred to as z-dol for simplicity.

The apparatus and techniques have been described in detail elsewhere (Rettner et al., 1986, 1989). Molecular beams of N_2 were scattered from the test surfaces and time of flight (TOF) distributions obtained for a range of incidence and final angles, θ_i and θ_f, for beam energies, E_i, up to ~0.2 eV. Figure 1 displays typical TOF distributions obtained in these studies. Results are displayed for N_2 scattering from a Pt(111) surface covered with z-dol for three different surface temperatures for E_i = 0.17 eV and $\theta_i = \theta_f$ = 60 deg. This figure illustrates the for E_I = 0.17eV and σ_i eq σ_f = 60°. This figure illustrates the manner in which the TOF distributions are fitted, assuming direct-inelastic (DI) and trapping-desorption (TD) scattering components (Barker and Auerbach, 1984). The measurements are indicated by the dots and the lines show the results of fits. The components of the fitted distribution are shown separately. It is clear that the results are in good agreement with this model. In order to quantify the fraction of molecules in the TD component, to obtain the trapping probability, S_0, the results have been integrated over all final angles. The resulting values of S_0 are given in Table 1. Information on the angular variations of the energy of the scattered molecules has been used to calculate the overall mean final energy, $\langle E_f \rangle$, for all the molecules scattered from the surface (DI plus TD components). These are also listed in Table 1 along with values for the thermal accommodation coefficient (Saxena and Joshi, 1981) σ_T, and the tangential momentum accommodation coefficient (Comsa et al., 1983) $\sigma_{//}$. The results for sputtered carbon indicate that $\sigma_{//} >$ 1 for this surface. This reflects the fact that the angular distribu-

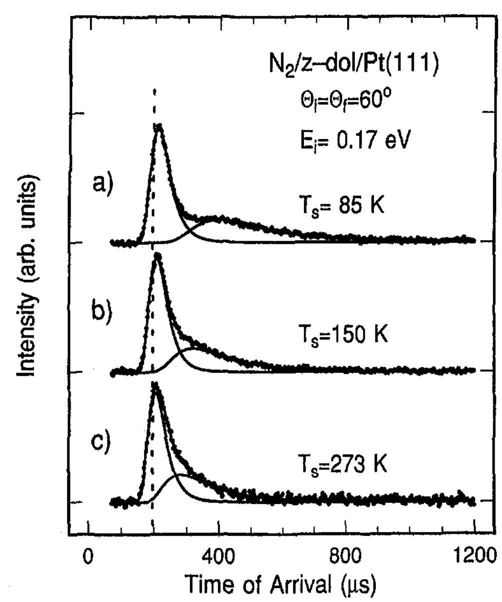

Fig. 1 Time-of-flight distributions of N_2 scattered from a z-dol/Pt(111) surface. Results are displayed for $\theta_i = \theta_f$ = 60 deg for surface temperatures of 85, 150, and 273 K. The incident N_2 had a mean kinetic energy of 0.17 eV. The curves indicate the results of fits to the data. The dashed line shows the time of arrival expected for the case of elastic scattering.

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Table 1 Characteristics for the scattering of N_2 from various surfaces. The thermal accommodation coefficient, σ_T, and the accommodation coefficient for parallel momemtum, σ_{II}, are defined in Eq. (1). The trapping probability, S_o, and the mean energy final energy, $\langle E_f \rangle$, are also given.

E_i (eV)	θ_i (deg)	$\langle E_f \rangle$ (eV)	σ_T	σ_{II}	S_o
z-dol/Pt (111) (T_s = 273 K)					
0.171	30.	0.064 ± 0.013	0.86 ± 0.11	0.82 ± 0.08	0.69 ± 0.10
0.171	45.	0.069 ± 0.009	0.83 ± 0.07	0.83 ± 0.06	0.65 ± 0.09
0.171	60.	0.075 ± 0.007	0.78 ± 0.06	0.82 ± 0.06	0.59 ± 0.07
0.086	30.	0.049 ± 0.004	0.94 ± 0.03	0.94 ± 0.04	0.92 ± 0.06
0.086	45.	0.049 ± 0.003	0.94 ± 0.03	0.94 ± 0.03	0.91 ± 0.05
0.086	60.	0.049 ± 0.003	0.95 ± 0.03	0.94 ± 0.03	0.91 ± 0.03
0.076	30.	0.048 ± 0.003	0.97 ± 0.03	0.96 ± 0.04	0.92 ± 0.04
0.076	45.	0.048 ± 0.002	0.96 ± 0.02	0.96 ± 0.03	0.92 ± 0.04
0.076	60.	0.049 ± 0.002	0.95 ± 0.02	0.94 ± 0.03	0.92 ± 0.03
Glass (T_s = 293 K)					
0.239	30.	0.088 ± 0.014	0.80 ± 0.07	0.85 ± 0.07	0.50 ± 0.10
0.239	45.	0.102 ± 0.010	0.73 ± 0.06	0.83 ± 0.06	0.45 ± 0.08
0.239	60.	0.124 ± 0.010	0.61 ± 0.06	0.80 ± 0.06	0.35 ± 0.07
0.082	30.	0.052 ± 0.003	0.95 ± 0.05	0.96 ± 0.05	0.96 ± 0.03
0.082	45.	0.053 ± 0.003	0.92 ± 0.05	0.94 ± 0.05	0.92 ± 0.05
0.082	60.	0.053 ± 0.003	0.92 ± 0.05	0.94 ± 0.04	0.90 ± 0.05
0.047	30.	0.051 ± 0.000	0.98 ± 0.02	0.98 ± 0.02	0.98 ± 0.02
0.047	45.	0.051 ± 0.000	0.98 ± 0.02	0.98 ± 0.02	0.98 ± 0.02
0.047	60.	0.051 ± 0.000	0.98 ± 0.02	0.98 ± 0.02	0.98 ± 0.02
Disk (T_s = 293 K)					
0.227	30.	0.088 ± 0.013	0.79 ± 0.08	0.84 ± 0.08	0.55 ± 0.08
0.227	45.	0.097 ± 0.010	0.74 ± 0.07	0.90 ± 0.07	0.45 ± 0.07
0.227	60.	0.111 ± 0.008	0.66 ± 0.05	0.88 ± 0.05	0.38 ± 0.07
0.082	30.	0.051 ± 0.003	0.97 ± 0.03	0.94 ± 0.04	0.94 ± 0.03
0.082	45.	0.052 ± 0.003	0.94 ± 0.05	0.95 ± 0.04	0.92 ± 0.03
0.082	60.	0.052 ± 0.003	0.94 ± 0.05	0.96 ± 0.04	0.91 ± 0.03
Sputtered carbon (T_s = 273 K)					
0.086	30.	0.047 ± 0.002	1.00 ± 0.05	> 1	0.98 ± 0.02
0.086	45.	0.047 ± 0.002	1.00 ± 0.05	> 1	0.98 ± 0.02
0.086	60.	0.047 ± 0.002	1.00 ± 0.05	> 1	0.98 ± 0.02

tions for N_2 scattering from this surface are clearly asymmetric about the surface normal, with less scattering to the specular side of normal than to the backscattering direction.

It is apparent from Table 1 that the accommodation coefficients and trapping probabilities decrease with increasing collision energy. The dependence of σ_{II} on E_i and θ_i for scattering from z-dol/Pt(111) and glass are very similar and can be summarized approximately by the expression

$$\sigma_{II}(E_i, \theta_i) = 1 - (1.05 - 0.36 \cos \theta_i) E_i(\text{eV}). \quad (1)$$

Averaging over a Boltzmann energy distribution for 293 K yields $\langle \sigma_{II} \rangle$ values of 0.96 ± 0.02 and $\langle \sigma_T \rangle = 0.97 \pm 0.02$. Considering that the accommodation and trapping at the disk and sputtered carbon samples is even higher, it is concluded that N_2 is essentially fully accommodated at energies characteristic of ambient room temperature gas. The only exception to this result is that the $\sigma_{\|}$ values for scattering from carbon appear to be slightly greater than unity. It is hoped that the results of this study will be of value to those using particle-based computational methods to simulate air-bearings at low fly heights. Moreover, the methodology employed in this study should be useful to others seeking to understand gas-surface accommodation in terms of gas-surface scattering.

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