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NEC电子公司与株式会社瑞萨科技于2010年4月1日进行业务整合（合并），整合后的新公司暨“瑞萨电子公司”继承两家公司的所有业务。因此，本资料中虽还保留有旧公司名称等标识，但是并不妨碍本资料的有效性，敬请谅解。

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2010年4月1日
瑞萨电子公司

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二极管

瑞萨二极管的可靠性

1. 二极管的可靠性

1.1 关于结构

二极管大致分为玻璃封装型和塑料封装型，在可靠性设计方面，需要分别注意。

玻璃封装型（密封封装）需要重点考虑密封性及使用元件间热膨胀系数相互匹配（DHD的情况下，芯片、引线柱螺栓以及玻璃外壳），从而确保热量以及机械强度。

不同封装的典型品种如**表1**所示，各品种请参照不同封装产品一览表以确认分类。

塑料封装型的情况下，重点在塑料材料、芯片表面稳定化技术（钝化规格）以及封装的结构设计上。

1.1.1 玻璃封装型的特点

(1) 密封性（耐湿性）良好，可靠性高。
(2) 小型、重量轻，容易安装。
(3) 双重散热板结构，散热性良好。
(4) 卷带包装或引脚成形（成形）容易，使套件组装合理化。

1.1.2 塑料封装型的特点

小型模制（MPAK等）二极管的情况下，有以下特点：

(1) 超小型，可贴面封装，适用于混合IC。
(2) 1个封装内可以装入多个芯片。
(3) 适用于超小型机器等的高密度安装。

1.2 可靠性数据

通过二极管的可靠性试验数据的具体例子进行说明。

(1) 故障判定标准例子
二极管的故障判定标准例子如**表2**所示。
(2) 二极管的可靠度试验数据
不同用途的工作寿命试验结果如**表3**所示，每种封装的环境试验结果如**表4**所示。
(3) 二极管的特性变动例子
在可靠度试验上，不仅要判定该产品的好坏，还要对特性的经时变化或特性分布进行探讨，并提供该产品的质量及可靠性评价。另外，在用户进行系统设计时，该数据还可作为电路设计等的容限设计的基础资料。
例如，根据齐纳二极管的工作寿命试验，齐纳电压及反向电流随时间变化的例子如**表5**所示，根据变容二极管的高温反向偏压试验，反向电流随时间变化的例子如**表6**所示。
(4) 不同故障模式的产生比率
在二极管的市场中不同故障模式产生比率，如**图1**（玻璃封装型二极管）、**图2**（塑料封装型二极管）所示。
如**图1**、**图2**所示，市场故障的8成以上是由器件损坏引起的。因此通过使用时的处理、特别是实施考虑了最大额定值的电路设计，可降低故障率。

表1　不同封装的典型品种

分类	封装	典型品种型号
玻璃封装	MHD	1SS270、 HZS系列
	DO-35	1S2076、 1SS106、 HZ系列
	DO-41	HZ-P系列
	LLD	HSK83、 HZK系列、 HSK120
塑料封装	MP6	RKP200KP、 RKV600KP、 RKV652KP
	MP8	RKP200KN、 RKD750KN
	TEFP	HVL142AM、 HVL355CM、 RKP201KM
	EFP	HVL142A、 HVL355C、 RKV650KL、 RKD700KL、 HSL226
	SFP	HVD142A、HVD355B、RKP201KK、RKV500KK、RKD700KK
	UFP	HVC355B、 RKV500KJ、 RKD700KJ、 HSC226
	TURP	HRV103A、 HRV103B
	URP	HVU355B、 HRU0302A、 RKV500KG、 HZU系列
	SRP	HVR100
	MPAK-5	HZM6.8MFA、 HZM27FA
	MPAK	HSM88AS、 HVM14S、 HVM16、 HZM-N系列、 HRW0202A
	CMPAK-4	HSB0104YP
	CMPAK	HVB14S
	VSON-5	RKZ6.8Z4MFAKT
	MFP12	RKP400KS、 RKP401KS、 RKP402KS
	MOP	HSB88WS
	MFPAK	HSN278WK

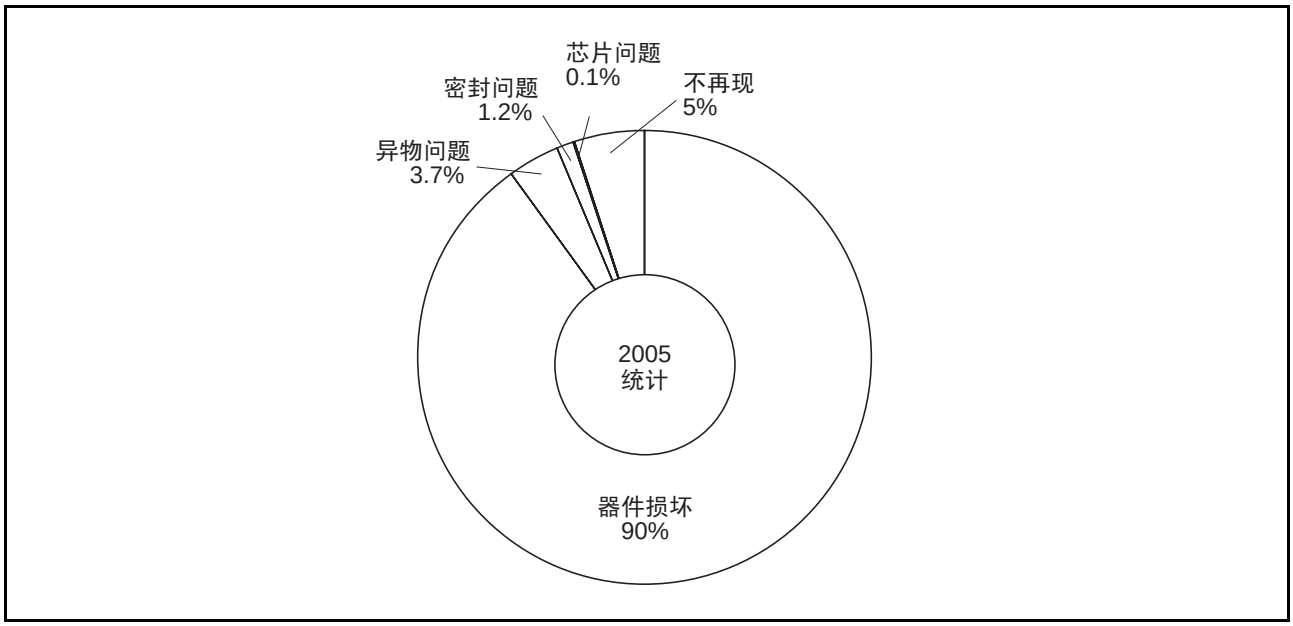


图1　玻璃封装型二极管的市场故障模式分类

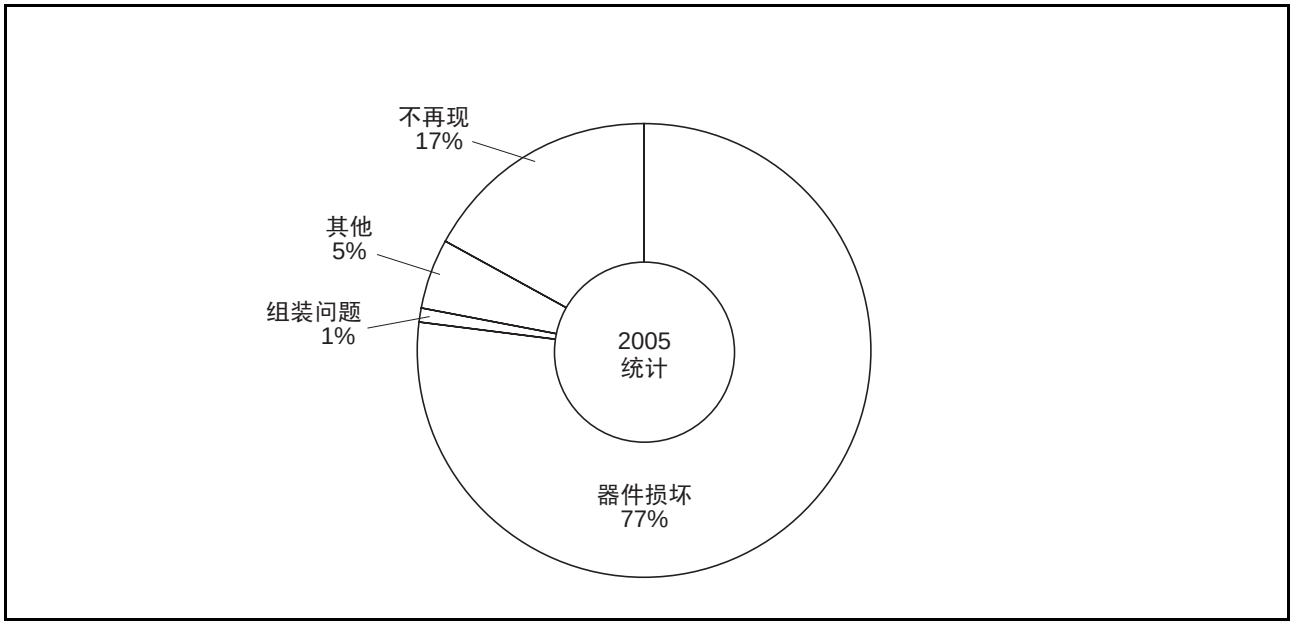


图2　塑料封装型二极管的市场故障模式分类

表2　二极管故障判定的标准例子

项目		故障判定标准*1		单位	备注
		最小	最大		
电特性	反向电压	L×0.9	—	V	
	反向电流	—	U×2	A	
	正向电压	—	U×1.1	V	
	齐纳电压变化率	−2	+2	%	
	断线、短路	断线、半断线、短路、半短路 } 也包含高/低温问题		—	
外观/其他	密封泄露	大泄露、小泄露		—	适用于玻璃封装型
	外观	依据限度样本		—	
	生锈、变色	依据限度样本		—	
	可焊性	依据限度样本		—	
	标识	依据限度样本		—	

【注】1. U：初期标准最大值
L：初期标准最小值

表3　工作寿命的试验结果(1)

No.	试验项目	试验条件	高速/高电压开关		高频开关		齐纳二极管	
			结果*1	故障率*2 (1/h)	结果*1	故障率*2 (1/h)	结果*1	故障率*2 (1/h)
1	连续工作(1)	相关标准：EIAJ-ED-4701 Ta=25±2°C, 试验时间：1000h	0/307	3.0×10^{-6}	0/60	1.5×10^{-5}	0/920	1×10^{-6}
	连续工作(2)	相关标准：EIAJ-ED-4701 Ta=25±2°C, I_O max., 试验时间：1000h	0/307	3.0×10^{-6}	0/60	1.5×10^{-5}	—	—
2	高温 反向偏压	相关标准：EIAJ-ED-4701 Ta=25±2°C, V_R max.,Tj max., 试验时间：1000h	0/307 3.0×10^{-6}	0/60	1.5×10^{-5}	—	—	—

【注】1. 故障数/试验数
2. 可靠标准60%

表3　工作寿命的试验结果(2)

No.	试验项目	试验条件	高速开关二极管		变容/PIN二极管	
			结果*1	故障率*2(1/h)	结果*1	故障率*2(1/h)
1	连续工作(1)	相关标准：EIAJ-ED-4701 Ta=25±2°C, 试验时间：1000h	—	—	0/60	1.5×10^{-5}
	连续工作(2)	相关标准：EIAJ-ED-4701 Ta=25±2°C,I_O max., 试验时间：1000h	0/614	1.5×10^{-6}	—	—
2	高温 反向偏压	相关标准：EIAJ-ED-4701 Ta=25±2°C, V_R max.,Tj max., 试验时间：1000h	0/307	3.0×10^{-6}	0/120	7.6×10^{-6}

【注】1. 故障数/试验数
2. 可靠标准60%

表4　环境试验结果(1)

No.	试验项目	试验条件		封装 玻璃 插入型 结果*1	故障率*2 (1/h)	SMD(LLD) 结果*1	故障率*2 (1/h)
1	焊料耐热性	相关标准：EIAJ-ED-4701 焊接温度：右侧记载 焊料浸渍时间：右侧记载 松香助焊剂浸渍：5～10s 浸渍到试验样品本体以下的1～1.5mm处。但是，DO-41浸渍至2～2.5mm处。 SMD整体为浸渍	260°C 10s	0/304	—	0/304	—
			350°C 3s	0/304	—	—	—
2	热冲击	相关标准：EIAJ-ED-4701 低温侧：0°C,5min. 高温侧：100°C,5min. 常温：10s以内 周期数：右侧记载	[周期] 10	0/152	—	0/152	—
			50	0/152	—	0/152	—
3	温度循环	相关标准：EIAJ-ED-4701 低温侧：Tstg min. 30min 高温侧：Tstg max. 30min 常温：10～15min 周期数：10周期		0/2304	—	0/2304	—
4	自然下落	相关标准：EIAJ-ED-4701 高度：75cm，厚度3cm的枫板上3次		0/2304	—	—	—
5	振动	相关标准：EIAJ-ED-4701 (1)可变频率振动 加速度：200m/s^2 频率：100～2000Hz XYZ方向各4次		0/152	—	0/152	—
6	冲击下落	相关标准：EIAJ-ED-4701 加速度：15000m/s^2 脉宽：0.5ms XYZ方向各3次		0/152	—	0/152	—

【注】1. 故障数/试验数
2. 可靠标准60%

No.	试验项目	试验条件	封装			
			玻璃			
			插入型		SMD(LLD)	
			结果*1	故障率*2 (1/h)	结果*1	故障率*2 (1/h)
7	引脚强度	相关标准：EIAJ-ED-4701 (1)拉伸 载重：依照EIAJ-ED-4701 持续时间：10s	0/304	—	—	—
		相关标准：EIAJ-ED-4701 (2)弯折 载重：依照EIAJ-ED-4701 反复两次90°弯折	0/304	—	—	—
		相关标准：EIAJ-ED-4131 (3)电路板弯曲 电路板支持间隔：90mm 电路板弯曲幅度：2mm	—	—	0/304	—
8	耐溶剂性	相关标准：EIAJ-ED-4131 异丙醇 浸渍时间：30s	0/152	—	0/152	—
9	盐水喷雾	相关标准：EIAJ-ED-4701 Ta=35°C 5%盐水雾中 试验时间：24h	0/152	—	0/152	—
10	元件强度	相关标准：EIAJ-ED-4131 (1)耐抗折力 施加压力：10N 加压时间：10±1s	—	—	0/304	—
		相关标准：瑞萨标准 (2)耐压缩力 施加压力：5N 加压时间：10±1s 向二极管本体的轴方向施加压力。	—	—	0/304	—
11	密封性	相关标准：EIAJ-ED-4701 浸水加压试验 加压：5.07×10^5 Pa 试验时间：2h	0/2304	—	0/2304	—
12	压力炉	相关标准：EIAJ-ED-4701 浸水加压试验 加压：2.03×10^5 Pa 试验时间：40h	—	—	—	—
13	高温高湿放置	相关标准：EIAJ-ED-4701 Ta=85°C、 85%RH 试验时间：1000h	0/920	1×10^{-6}	0/920	1×10^{-6}
14	高温高湿 反向偏压	相关标准：EIAJ-ED-4701 Ta=85°C、 85%RH V_R max 试验时间：1000h	0/920	1×10^{-6}	0/920	1×10^{-6}
15	高温放置	相关标准：EIAJ-ED-4701 Tstg max 试验时间：1000h	0/230	4×10^{-6}	0/230	4×10^{-6}
16	低温放置	相关标准：EIAJ-ED-4701 Tstg min 试验时间：1000h	0/230	4×10^{-6}	0/230	4×10^{-6}

【注】1. 故障数/试验数
2. 可靠标准60%

表4　环境试验结果(2)

No.	试验项目	试验条件		封装			
				塑料			
				SMD1*3		SMD2*4	
				结果*1	故障率*2 (1/h)	结果*1	故障率*2 (1/h)
1	焊料耐热性	相关标准：EIAJ-ED-4701 焊接温度：260°C 焊料浸渍时间：10s 松香助焊剂浸渍：5～10s SMD为整体浸渍。		0/180	—	0/88	—
2	焊接性	相关标准：EIAJ-ED-4701 焊接温度：235°C±5°C 焊料浸渍时间：5±0.5s 松香助焊剂浸渍：5～10s SMD为整体浸渍。		0/180	—	0/88	—
		相关标准：EIAJ-ED-4701 焊接时间：235°C±5°C 焊料浸渍时间：5±0.5s 松香助焊剂浸渍：5～10s SMD为整体浸渍。		0/180	—	0/88	—
3	热冲击	相关标准：EIAJ-ED-4701 低温侧：0°C、 5min. 高温侧：100°C、 5min.	[周期] 10	0/180	—	0/88	—
		常温：10s以内 周期数：右侧记载	50	0/180	—	0/88	—
4	温度循环	相关标准：EIAJ-ED-4701 低温侧：Tstg min. 30min 高温侧：Tstg max. 30min 常温：10～15min 周期数：10周期		0/3068	—	0/1155	—
5	自然下落	相关标准：EIAJ-ED-4701 高度：75cm、厚度3cm的枫板上3次		0/3068	—	0/1844	—
6	振动	相关标准：EIAJ-ED-4701 (1)可变频率振动 加速度：200m/s^2 频率：100～2000Hz XYZ方向各4次		0/60	—	0/60	—
7	冲击下落	相关标准：EIAJ-ED-4701 加速度：15000m/s^2 脉宽：0.5ms XYZ方向各3次		0/60	—	0/60	—
8	引脚强度	相关标准：EIAJ-ED-4701 (1)拉伸 载重：依照EIAJ-ED-4701 持续时间：10s		0/180	—	0/88	—
9	耐溶剂性	相关标准：EIAJ-ED-4131 异丙醇 浸渍时间：30s		0/60	—	0/60	—

【注】1. 故障数/试验数
2. 可靠标准60%
3. SMD1：MPAK、 CMPAK、 MOP
4. SMD2：SRP、 URP、 UFP、 SFP

No.	试验项目	试验条件	封装			
			塑料			
			SMD1*3		SMD2*4	
			结果*1	故障率*2 (1/h)	结果*1	故障率*2 (1/h)
10	盐水喷雾	相关标准：EIAJ-ED-4701 Ta=35°C 5%盐水雾中 试验时间：24h	0/180	—	0/88	—
11	压力炉	相关标准：EIAJ-ED-4701 浸水加压试验 加压：2.03×10^5 Pa 试验时间：40h	0/180	1.28×10^{-4}	0/88	2.6×10^{-4}
12	高温高湿放置	相关标准：EIAJ-ED-4701 Ta=65°C、 95%RH 试验时间：1000h	0/1840	5×10^{-7}	0/920	1×10^{-6}
13	高温高湿 反向偏压	相关标准：EIAJ-ED-4701 Ta=85°C、 85%RH V_R max 试验时间：1000h	0/1840	5×10^{-7}	0/920	1×10^{-6}
14	高温放置	相关标准：EIAJ-ED-4701 Tstg max 试验时间：1000h	0/735	1.25×10^{-6}	0/185	5×10^{-6}
15	低温放置	相关标准：EIAJ-ED-4701 Tstg min 试验时间：1000h	0/735	1.25×10^{-6}	0/185	5×10^{-6}

【注】1. 故障数/试验数
2. 可靠标准60%
3. SMD1：MPAK、 CMPAK、 MOP
4. SMD2：SRP、 URP、 UFP、 SFP

表5　齐纳二极管的特性变动例子

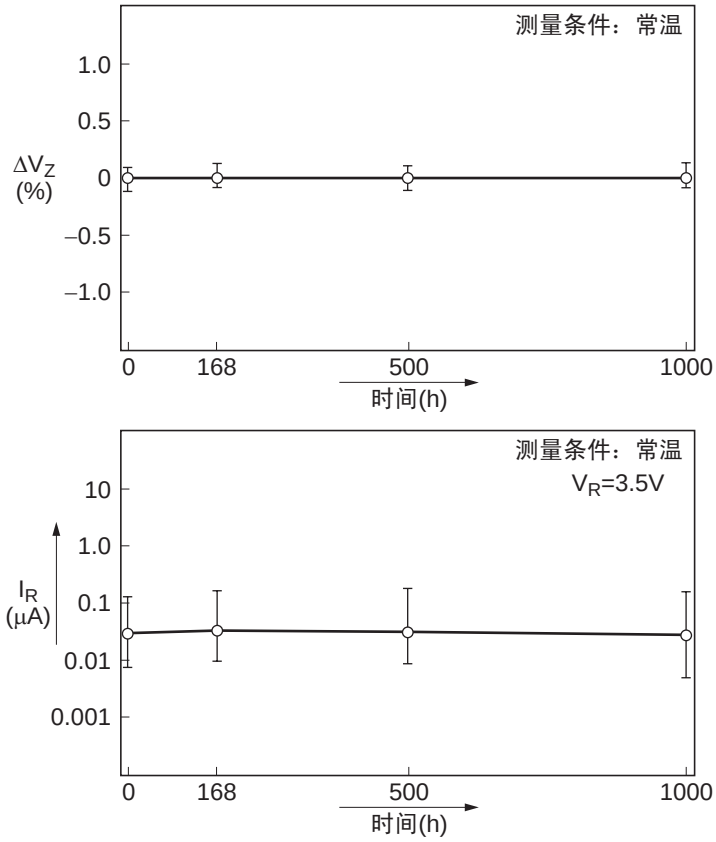
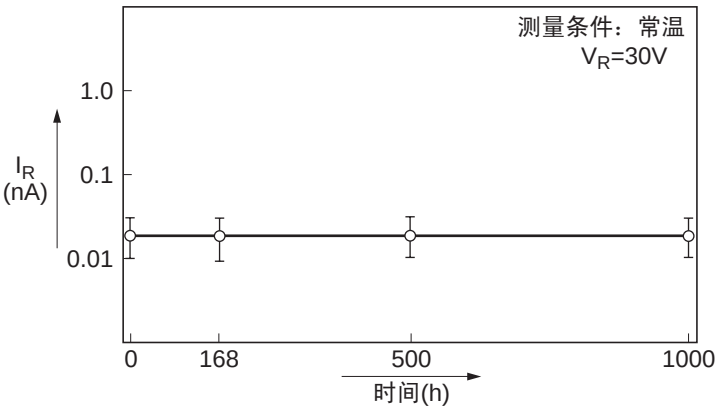
特性变动例子		齐纳二极管工作寿命试验引发的V_Z、I_R经时变化
型号	HZ7	
试验条件	Ta=25°C Pd=500mW	
试验数	200个	
故障判定标准	V_Z=初始值±2% I_R=不超过2μA	
故障机理	表面老化	
结果说明： (1) V_Z、I_R都随时间稳定变化。 (2) V_Z、I_R都在初始标准内，未超过故障判定标准。		

表6　变容二极管的特性变动例子

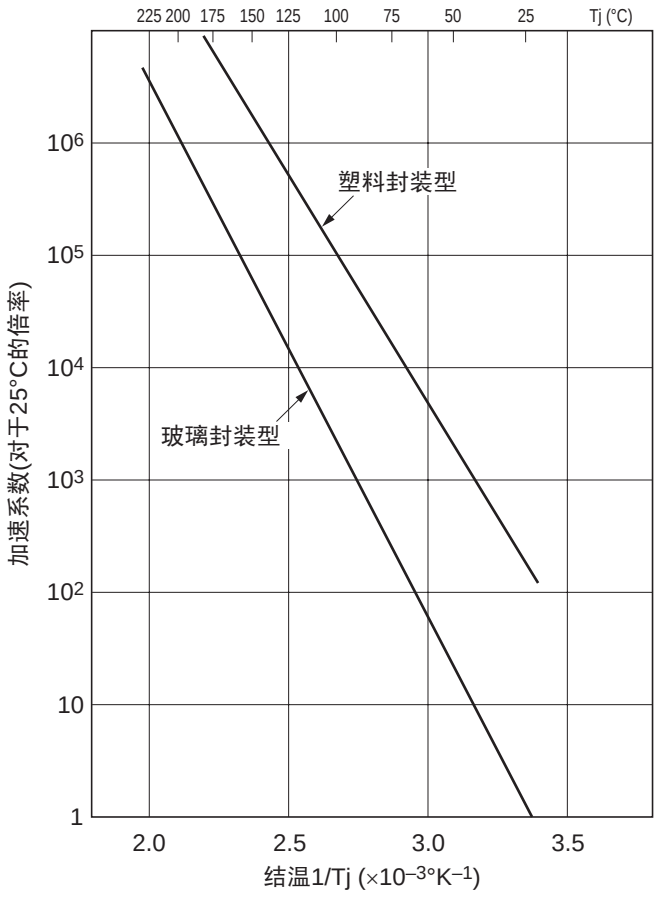
特性变动例子		变容二极管的高温高湿反向偏压试验引发的I_R经时变化
型号	HVU200A	
试验条件	Ta=85°C、 RH=85% V_R=30V （连续）	
试验数	60个	
故障判定标准	I_R=20nA (V_R=30V)	
故障机理	表面老化	
说明结果： (1) I_R 分布的变动小，在初始标准内，未超过故障判定标准。		

(5) 故障率和减额

从各种可靠性试验结果可知，为确保实际使用时设备的可靠性，必须对环境温度或功耗等热应力进行减额，从而有效降低故障率。

二极管的减额特性如表7所示。从此数据可以看出，使用时不能超过最大额定值。

表7 二极管的减额特性

<table>
<tr><th colspan="3">高速开关二极管的减额应用例子</th></tr>
<tr><td>应力因素</td><td>Pd、 Ta</td><td rowspan="6"> 
</td></tr>
<tr><td>故障判定标准</td><td>断线、短路
特性老化</td></tr>
<tr><td>故障机理</td><td>正面/反面电极老化
结老化</td></tr>
<tr><td colspan="2">概要
通过在可加速范围内改变结温条件来进行高速开关二极管的工作寿命试验。
根据各结温与故障率的关系，求出加速系数，如右图。</td></tr>
<tr><td colspan="2">减额数据的使用方法</td></tr>
<tr><td colspan="2">在确认规定的Tj故障率时，可求出右图中任意温度上的故障率。
[例]玻璃封装型的情况下，在Tj=100°C的故障率为100[FIT]时，计算在Tj=50°C时的故障率。
根据右图可知， 100°C、 50°C时的加速系数对25°C的倍率分别为1800、18，所以50°C时的故障率是100°C时的1/100。从而， 50°C时的故障为100/100=1[FIT]。</td></tr>
</table>

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